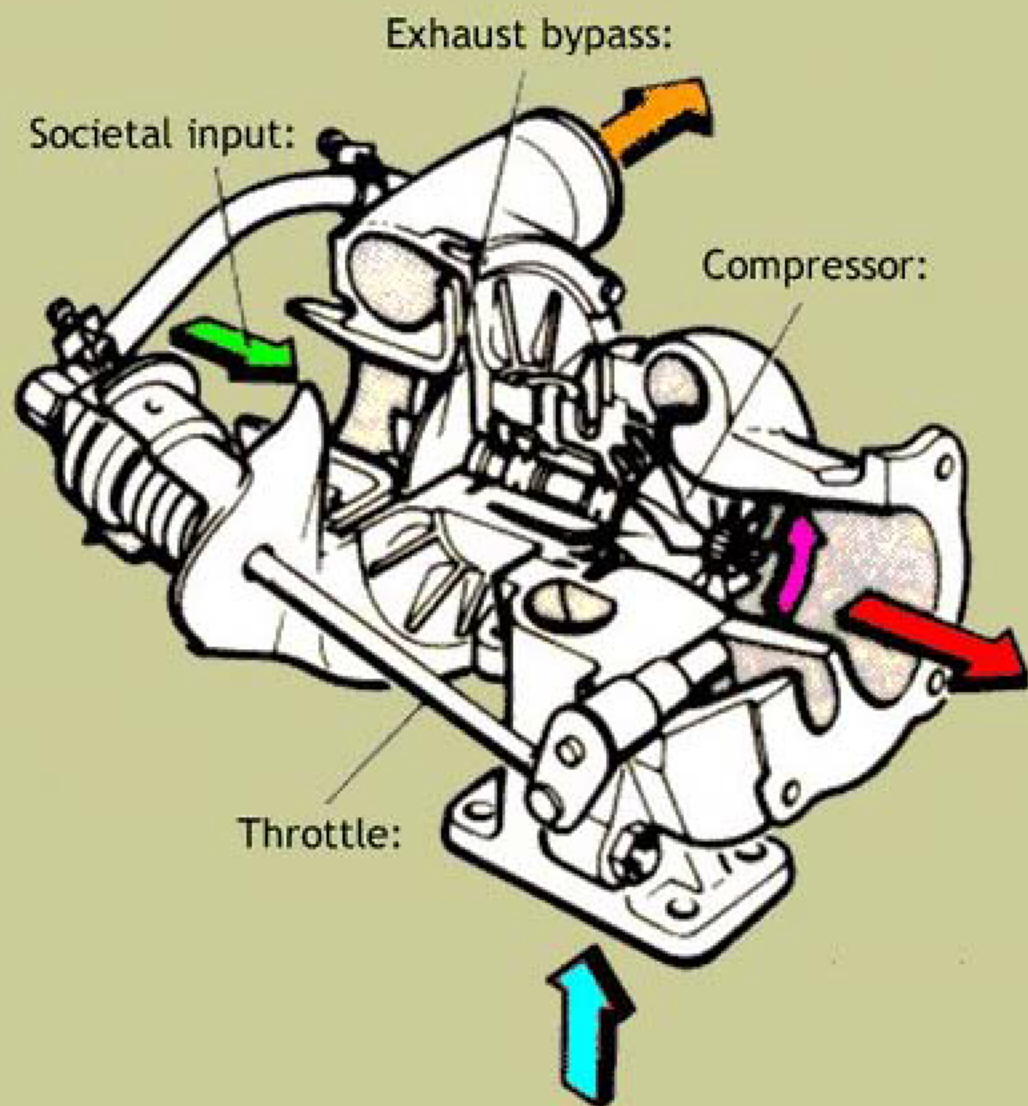
Gilbert Simondon:
On the Mode of Existence of Technical Objects



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INTRODUCTION

The purpose of this study is to create an awareness of the significance of technical objects. Culture has become a system of defense against technics; now, this defense appears as a defense of man based on the assumption that technical objects contain no human reality. We should like to show that culture fails to take into account that there is a human reality in technical reality and that, if it is to fully play its role, culture must come to incorporate technical entities into its body of knowledge and its sense of values. Recognition of the modes of existence of technical objects should be the result of philosophical thought, which in this respect has to achieve what is analogous to the role it played in the abolition of slavery and in the affirmation of the value of the human person. The opposition established between culture and technology, between man and machine, is false and is not well-founded; what underlies it is mere ignorance or resentment. Behind the mask of a facile humanism it hides a reality that is rich in human efforts and natural forces, a reality that constitutes the world of technical objects, mediators between nature and man.

Culture behaves towards the technical object in much the same way as man who allows himself to be swept along by primitive xenophobia behaves towards a stranger. The kind of misoneism directed towards machines is not so much a hatred of the new as a refusal to come to terms with an alien reality. Now this alien being is also human, and a complete culture is one that makes it possible to discover that the alien is human. Similarly, the machine is an alien; it is an alien that has something of the human is locked in, unrecognized, materialized, enslaved, but human nonetheless. The most powerful cause of alienation in the contemporary world resides in this failure to understand the machine, which is not caused by the machine but by the non-understanding of its nature and its essence, by its absence from the world of meanings, and by its omission from the table of values and concepts that are part of culture.

Culture is unbalanced because it recognizes certain objects, such as the aesthetic object, and accords them their due place in the world of meanings, while it pushes back other objects, and particularly technical objects, to the unstructured world of things that have no meanings but do have a use, a utilitarian function. Faced with this defensive denial decided by a partial culture, men who have knowledge of technical objects and who appreciate their significance try to justify their judgment by giving the technical object the status of a sacred object, the only status that today prized apart from that of the aesthetic object. Then an intemperate technicism comes into existence that is nothing other than idolatry of the machine, and through this idolatry, by means of identification, a technocratic aspiration for unconditional power arises. The desire for power confirms the machine as a way to supremacy, and makes of it the modern philter. The man who wishes to dominate his fellows creates the android machine. He abdicates in favor of it and delegates his humanity to it. He tries to construct the thinking machine and dreams of being able to construct the willing machine, the living machine, so that he

can remain behind it without anxiety, freed from all danger, exempt from every feeling of weakness, and enjoying a vicarious triumph through what he has invented. Now, in this case, once the machine, according to the imagination, has become a duplicate of man, a robot, with no interiority, it is quite evidently and inevitably a purely mythic and imaginary being.

We would like to show precisely that there is no such thing as the robot, that it is no more a machine than a statue is a living being, that it is merely a product of the imagination, of fictive fabrication, of the art of illusion. Nevertheless, the notion of the machine in present-day culture to a considerable extent incorporates this mythic representation of the robot. No well-read man would allow himself to speak of objects or persons painted on canvas as genuine realities with an interior life and a will, whether good or bad. Despite this, the same man speaks of machines that threaten man as if attributing to those objects a soul and a separate and autonomous existence, which suggests that they have feelings and intentions towards man.

So culture has *two contradictory attitudes* towards technical objects: on the one hand, it treats them as pure *assemblages of matter* devoid of true meaning and only providing utility. On the other hand, culture assumes that these objects are also robots, and that they have hostile *intentions* to man or that they represent for him a constant danger of aggression, of insurrection. Judging it good to preserve the first characteristic, culture strives to prevent the manifestation of the second, and speaks of putting machines in the service of man, in the belief that reduction to slavery is a sure way to prevent rebellion.

In fact, this contradiction in culture arises from ambiguity in ideas concerning automatism, ideas in which there lurks a truly logical flaw. In general, idolaters of the machine affirm that the degree of perfection of a machine is proportional to its degree of automatism. Going beyond what experience demonstrates they assume that an increase and improvement in automatism would lead to a bringing together and a mutual interconnecting of all machines, so as to constitute a machine made up of all machines.

Now, in fact, automatism is a fairly low degree of technical perfection. To make a machine automatic, it is necessary to sacrifice many of its functional possibilities and many of its possible uses. Automatism, and the use of it in the form of industrial organization called *automation*, has an economic or social rather than a technical significance. The real improvement of machines, that which can be said to raise the level of technicity, has nothing to do with an increase in automatism but, on the contrary, with the fact that the functioning of a machine conceals a certain margin of indeterminacy. It is this margin that allows a machine to be sensitive to outside information. It is this sensitivity of machines to information, much more than by any increase in automation, that makes possible the materialization of a technical ensemble. A purely automatic machine, completely self-enclosed in a predetermined functioning, could only provide summary results. The machine that is endowed with a high technicity is an open machine, and the ensemble of open machines assumes man as a permanent organizer, as a living interpreter of the interrelationships of machines. Far from being the supervisor of a gang of slaves, man is the permanent organizer of a society of technical objects that need him in the way musicians need an orchestra conductor. The orchestra conductor can direct his musicians only because, like them, and as intensely as they, he can play the piece being performed; he slows them down or speeds them up, but is also slowed

down or sped up by them; in fact, the group of musicians slows down and speeds up each member of the group trough him, [and] for each of them he is the current moving form of the group in its very act of existing; he is the interpreter of all of them in relation to all. This is how man has the function of being the permanent coordinator and inventor of the machines around him. He is *among* the machines that work with him.

The presence of man among machines is a living creation. What resides in machines is human reality, human action fixed and crystallized in functioning structures. These structures have a need to be maintained in the course of their functioning, and the greatest perfection coincides with the greatest openness, with the greatest possible freedom in functioning. Modern calculators are not pure automata; they are technical beings which, over and above their automatisms of adding (or of decision through the operation of elementary rockers), have very wide possibilities of circuit switching that make it possible to program the operation of the machine by limiting its margin of indeterminacy. It is because of this original margin of indeterminacy that that the same machine can work out cubic roots or translate a simple text composed of a small number of words and turns of phrase from one language to another.

It is also by the instrumentality of this margin of indeterminacy, and not by automatisms, that machines can be grouped into coherent ensembles so as to exchange information with each other through the agency of the human interpreter as coordinator. Even when the exchange of information between the two machines is direct (such as between a master oscillator and another oscillator that is pulse synchronized), man intervenes as the being who regulates the margin of indeterminacy so as to make it adaptable to the best possible exchange of information.

Now, we could wonder what man is able to reach an understanding of technical reality, and can then introduce it into culture. To arrive at such an understanding would be very difficult for someone who is attached to a single machine in the routine of daily actions at work; a traditional work relationship does not favor such an understanding, because doing the same thing over and over in the stereotypy of learned acts blurs the awareness of structures and of actions. The fact of managing a business that uses machines, or the connection of being an owner, has no advantage over the labor regarding this understanding: it creates abstract attitudes about the machine, which is not judges for what it is but in terms of cost and the products of its operation. Neither is scientific knowledge, which sees in a technical object the practical application of a theoretical law, on the proper level of the technical domain. Rather, it would seem that the technical understanding of which we speak could be the achievement of an organization engineer who would be, as it were, the sociologist and psychologist of machines, a person living in the midst of this society of technical beings as its responsible and creative conscience.

A genuine understanding of the significance of technical realities corresponds to an open plurality of technics. Moreover, it cannot be otherwise, because even an ensemble of machines that is small in scope involves machines whose operational principles arise from very different scientific domains. So-called technical specialization most often corresponds to preoccupations that are unrelated to technical objects properly so called (public relations, a private form of commerce), and not to any of the operational schemes appropriate to technical objects; specialization depending on directions unrelated to technics is what creates the regrettable narrowness of attitudes attributed to

technicians by the well-read man who wants to be different from them: what is in question is a narrowness of intent, and of aim, rather than a narrowness of information or intuition regarding techics. In our day there are very few machines that are not all at once in some way mechanical and thermal and electric.

In order to restore to culture the really general character that it has lost, it must be possible to reintroduce in it an understanding of the nature of machines, their mutual relations, their relations with man, and the values involved in these relations. This understanding calls for the existence, side by side with the sociologist and the psychologist, of the technologist or the *mechanologist*. Further, the basic schemes of causality and regulation that constitute an axiomatic of technology should be taught universally in the way that the fundamentals of literary culture are taught. Initiation to technics should be placed on the same level as scientific education; it is as objective as the use of the arts, and it influences practical applications as much as do theoretical physics; it is able to reach the same degree of abstraction and symbolization. A child should know self-regulation and positive reaction as well as he knows mathematical theorems.

This reform of culture, carried out by a process of expansion and not by destruction, could give back to present-day culture the real regulatory power it has lost. Being the base of meanings, of means of expression, of proofs and of forms, a culture establishes regulatory communication among those who share that culture; arising from the life of the group, it informs the actions of those who insure functions of control by providing them with norms and schemes. Now, before the great development of technics, culture incorporated as schemes, symbols, qualities, and analogues, the main kinds of technics giving rise to living experience. On the other hand, present-day culture is ancient culture that has incorporated as dynamic schemes the state of artisanal and agricultural crafts of past centuries. And those schemes serve as mediators between groups and their leaders, giving rise to a basic distortion because of their unsuitability to technics. Power becomes literature, an art of opinion, an argument for likelihood, rhetoric. Functions of guidance are false, because an adequate code of relations no longer exists between governed reality and the beings who govern: governed reality includes men and machines; the code is based solely on the experience of man working with tools, the same experience being both weakened and remote because those who use the code are not at all like Cincinnatus, who had just let go of the handles of the plough. To put it simply, the symbol is weakening, reality is absent. A regulatory relationship of circular causality cannot be established between the whole of governed reality and the function of authority: information no longer achieves its purpose because the code has become inadequate for the type of information it should transmit. Information that will express the simultaneous and correlative existence of men and machines should include the operational schemes of machines and the values that they imply. Culture, which has become specialized and impoverished, must once again become general. Such an extension of culture has political and social value because it suppresses one of the main causes of alienation and because it reestablishes regulatory information: it can give man ways of thinking about his existence and his situation in terms of the reality that surrounds him. This work of enlarging and deepening culture also has an especially

philosophical role to play because it leads to the criticism of a certain number of myths and stereotypes, such as that of the robot, or of perfect automata in the service of lazy and gratified humanity.

To bring about this understanding, it is possible to attempt to define the technical object in itself, by the process of concretization and functional over-determination which gives it its consistency as the end-product of an evolution, proving that it should not be considered a mere utensil. The modalities of this genesis make it possible to grasp the three levels of the technical object and their temporal, non-dialectic coordination: the element, the individual, and the ensemble.

Once the technical object has been defined in terms of its genesis, it is possible to study relationships between the technical object and other realities, especially the human as adult and as child.

Finally, considered as the object of an assessment of values, the technical object can give rise to very different attitudes, depending on whether it is taken at the level of the element, at the level of the individual, or at the level of the ensemble. At the level of the element, its improvement causes no anxiety-provoking confusion because of conflict with acquired habits: it leads to the climate of optimism of the eighteenth century, which introduced the idea of a continuous and indefinite progress assuring a constant improvement of man's lot. On the other hand, the technical individual becomes for a time the adversary of man, his rival, because man centralized technical individuality in himself at a time when only tools existed; the machine takes the place of man because man as tool-bearer did the job of a machine. This phase corresponds to a dramatic and impassioned notion of progress, which becomes a rape of nature, a conquest of the world, a harnessing of energies. This will to power is expressed through the technicistic and the technocratic excesses of the thermodynamic era, which has taken a turn both prophetic and cataclysmal. Lastly, at the level of the technical ensembles of the twentieth century, thermodynamic energy is replaced by information theory, the normative content of which is eminently regulatory and stabilizing: the development of technics appears as a guarantee of stability. The machine, as an element in the technical world, becomes something that augments the quantity of information, that increases negentropy, and that resists the degradation of energy: the machine, a work of organization, of information, like life and with life, is something that opposes disorder and opposes the leveling of everything that tends to deprive the universe of its power to change. The machine is something man uses to oppose the death of the universe; like life, it slows down the degradation of energy and becomes the stabilizer of the world.

This modification of the philosophic view of the technical object heralds the possibility of an introduction of the technical being into culture: this integration, which was not possible in a definitive way either at the level of element s or at the level of the individuals, is possible and has a greater likelihood of stability at the level of ensembles; once technical reality has become regulatory, it can be integrated into culture, which is essentially regulatory. This integration could only have been done by addition in the time when technicity resided in elements, by burglary or revolution in the time when technicity resided in the new technical individuals; today, technicity tends to reside in ensembles; that is why it can become a basis for the culture to which it will bring a power of unity and stability, by making it appropriate to the reality which it expresses and which it regulates.

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FIRST PART

THE GENESIS AND EVOLUTION OF TECHNICAL OBJECTS

CHAPTER I

THE GENESIS OF THE TECHNICAL OBJECT: THE PROCESS OF CONCRETIZATION

I.-- THE ABSTRACT TECHNICAL OBJECT AND THE CONCRETE TECHNICAL OBJECT

Every technical object is submitted to a genesis, but it is difficult to define the genesis of each technical object, because the individuality of technical objects is modified in the course of the genesis; what can be done is to define technical objects with reference to the technical species to which they belong, though to do so involves some difficulty; species are easy to identify summarily for practical purposes, insofar as we are willing to understand the technical object in terms of the practical end it is designed meet; but here there a matter of illusory specificity, because no fixed structure corresponds to its defined use. The same outcome can be obtained from very different operations and structures: a steam engine, a petrol engine, a turbine, and an engine powered by springs and weights are all engines; and yet, there is a more apt analogy between a spring engine and a bow or crossbow than between the spring engine and a steam engine; a clock driven by weights has an engine analogous to a winch, whereas an electric clock is analogous to a doorbell or buzzer. Usage brings together heterogeneous structures and operations in genera and species that get their meaning from the relationship between their particular function and another function, that of the human being in action. So, anything to which we give a particular name, that of engine, for example, can perhaps be multiple at any moment and can vary with time as it changes its individuality.

However, in trying to define the laws of the genesis of the technical object in the framework of its individuality and specificity, instead of starting from the individuality of the technical object or even from its specificity, which is quite unstable, it is preferable to reverse the problem: it is on the basis of the criteria of its genesis that the individuality and the specificity of the technical object can be defined: the individual technical object is not a datum of the here and now (*une chose donnée hic et nunc*) but something that has a genesis.[1] The unity of the technical object, its individuality, and its specificity, are

[1] [That is] according to given modalities that distinguish the genesis of the technical object from those of other kinds of objects: the aesthetic object, the living being. These specific modalities of genesis should be distinguished from a static specificity that could be established following the genesis of the object by taking into account characteristics of various types of objects; the precise goal in using the genetic method is to avoid the use of classifying thinking that come into play once the genesis is complete to divide all objects into genera and species suitable for discourse. The

consistent and convergent characteristics of its genesis. The genesis of the technical object is part of its being. The technical object is something that does not exist prior to its becoming, but that is present at every stage of that becoming; the technical object is a unit of becoming. The petrol engine is not any particular engine produced in time and in space, but the evidence that there is a sequence or continuity from the first engines to those we know and to those that are still in evolution. Consequently, as in a philogenetic lineage, a defined stage of evolution contains within itself structures and dynamic schemes that are at the beginning of any evolution of forms. The technical being evolves by convergence and by adaptation to itself; it is unified from within according to a principle of internal resonance. The automobile engine of today is not a descendant of the 1910 engine, simply because the 1910 engine was the one our ancestors built. Neither is it a descendent of that engine because of greater improvement in relation to use; indeed, for some uses the 1910 engine is better than a 1956 engine. For example, it can withstand a high degree of heating without jamming or leaking, because it is constructed with greater play and without fragile alloys such as babbitt metal; it is more autonomous because it has magneto ignition. Old engines work on fishing boats without breaking down after being taken out of worn-out cars. The reason present day car engine is defined as later than the 1910 engine. It is only through an internal examination of its systems of causality and of its forms as adapted to those systems of causality that the present-day engine can be defined as later than the 1910 engine. In the current engine every critical piece is so well connected with the rest by reciprocal exchanges of energy that it cannot be other than it is. The shape of the cylinder, the shape and size of the valves, and the shape of the piston are all part of the same system in which a multitude of reciprocal causalities exist. To the shape of these elements there is a corresponding rate of compression, which itself requires a specified degree of ignition advance; the shape of the cylinder head, the metal of which it is made, produce in relation to all other elements of the cycle, a certain temperature in the spark-plug electrodes; in turn, this temperature affects the characteristics of the ignition and, as a result, of the whole cycle. We could say that the present-day engine is a concrete engine, whereas the old engine was an abstract engine. In the old engine, each element comes into play at a certain moment in the cycle, and then it is supposed to have no effect on the other elements; the different parts of the engine are like individuals who could be thought of as working each in his turn without their ever knowing one another.

This is very much how the functioning of thermal engines is explained in the classroom, each part being isolated from the rest, *partes extra partes* in geometric space, just like the lines that represents it on the blackboard. The early engine is a logical assembly of elements defined by their complete and single function. Each element can best complete its own function if it is like a perfectly finalized instrument that is completely oriented towards the performance of that function. A permanent exchange of energy

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past evolution of a technical object remains as an essential of this being in the form of technicity. The technical being, a bearer of technicity according to the thought process we shall call analytical, cannot be an object of adequate knowledge unless the knowledge in question grasps the temporal meaning of its evolution; this adequate knowledge is technical culture, as distinct from technical knowledge which is limited to the understanding of everyday applications of isolated schemes of functioning. Since on the level of technicity relationships between one technical object and another are horizontal as well as vertical, the kind of knowledge that proceeds through genus and species is not suitable: we shall try to indicate in what sense the relationship between technical objects is transductive.

between two elements appears as an imperfection if this exchange is not part of the theoretical functioning; also, there exists a primitive form of the technical object, *the abstract form*, in which each theoretical and material unit is treated as an absolute, that has an intrinsic perfection of its own and needs to be constituted in a closed system in order to function; integration into the ensemble in this case involves a series of problems to be resolved, problems that are called technical and that are, in fact, problems of incompatibility between already established ensembles.

These already established ensembles ought to be maintained and, despite their reciprocal influences, preserved. Then there appear particular structures which, in the case of each of their constituent units, we might call defense structures: the cylinder-head of the thermal internal combustion engine bristles with cooling fins specially developed in the valve region and subject to intense thermal exchanges and to high pressures. In early engines those cooling fins are as it were extraneously added to the cylinder and to the cylinder-head which, in theory, are geometrically cylindrical: they fulfill a single function only, that of cooling. In recent engines, these fins play an added role of a mechanical kind, as ribs preventing the buckling of the cylinder-head under gaseous thrust; in these conditions it is impossible to distinguish the volumetric unit (cylinder, cylinder-head) from the heat-dissipation unit; if by sawing or grinding one were to remove the fins of an air-cooled engine, the volumetric unit constituted by the cylinder alone would no longer be viable, not even as a volumetric unit: it would buckle under gaseous pressure; the volumetric and mechanical has become coextensive with the heat-dispersal unit, because the structure of the ensemble has become bivalent: the fins, in relationship with currents of outside air, through thermal exchanges, constitute a cooling surface: insofar as they are part of the cylinder, those same fins limit the size of the combustion chamber by a non-deformable contour that uses less metal than a non-ribbed shell would require. The development of this single structure is not a compromise but a concomitance and a convergence: a ribbed cylinder can be thinner than a smooth cylinder-head with the same rigidity; in addition, a thin cylinder-head makes possible more efficient thermal exchanges than those that would be possible with a thick cylinder-head; the bivalent fin-rib structure improves cooling not only by enlarging the thermal-exchange surface (this is the function of the fin as fin) but also by making possible a thinner cylinder-head (and this is the function of the fin as rib).

Therefore, the technical problem has more to do with the convergence of functions in a structural unit than with the search for compromise between conflicting requirements. If, in the case in question, the conflict between the two aspects of the single structure subsists, it can only be possible to the extent that the position of ribs for maximum rigidity is not necessarily what is suitable for maximum cooling in facilitating the flow of air between fins when the vehicle is running. In this case, the manufacturer can be obliged to retain a dual, incomplete feature [*un caractère mixte incomplet*]: if the fin-ribs are arranged for the best cooling possible, they should be heavier and more rigid than if they were ribs only. If, on the other hand, they are arranged so as to solve perfectly the problem of achieving rigidity, they have a larger surface, in order to regain by an extension of the surface what was lost in the heat-exchange process by the slowing down of air currents; indeed, in their very structure the fins can be a compromise between the two forms, which makes necessary a larger expansion [of the surface] than if one of its function had been established as the purpose of the structure. This divergence of

functional aims remains as a residue of abstraction in the technical object, and the progressive reduction of this margin between functions of polyvalent structures is what defines the progress of a technical object; it is this convergence that specifies the technical object, because an infinite plurality of functional systems is not possible in a any age; technical species are far fewer in number than the designated uses of technical objects; human needs diversify to infinity, but the aims of convergence of technical species are finite in number.

The technical object exists, then, as a specific type that is arrived at the end of a convergent series. This series goes from the abstract mode to the concrete mode: it tends towards a state at which the technical being becomes a system absolutely coherent with itself, absolutely unified.

II. – THE CONDITIONS OF TECHNICAL EVOLUTION

What are the *reasons* for the convergence that is manifest in the evolution of technical structures? – No doubt there are a certain number of extrinsic causes, particularly those that tend to produce standardized items and spare parts. At the same time, extrinsic causes are no more powerful than those that tend towards the multiplication of types in response to the infinite variety of needs. If technical objects evolve in the direction of a small number of specific types, it is by virtue of an internal necessity and not as a consequence of economic influences or practical demands; it is not the production-line that produces standardization; rather, it is intrinsic standardization that makes production-line work possible. An effort to discover, in the movement from artisanal production to industrial production, the reason for the production of specific types of technical objects would mistake the consequence for the condition; industrialization of production is made possible by the stabilization of stable types. Handicraft [*l'artisanat*] corresponds to the primitive stage of the evolution of technical objects, that is to say, to the abstract stage; industry corresponds to the concrete stage. The *made-to-measure* character we discover in the product of the craftsman is not essential; it derives from another, though essential, character of the abstract technical object, which is based on an analytical organization that always leaves the way clear for new possibilities; these possibilities are the outer manifestation of an inner contingency. In the encounter between the coherence of technical work and the coherence of system needs in utilization, the coherence of utilization is what prevails because the made-to-measure technical object is in fact one that has no intrinsic standard; its norms are imposed from without: it has not achieved its internal coherence; it is not a system of the necessary; it corresponds to an open system of demands.

On the other hand, the object has achieved its coherence at the industrial level, and here the system of needs is less coherent than the system of the object; needs are molded on the industrial technical object, which thereby acquires the power to shape a civilization. Utilization becomes an ensemble cut to the measures of the technical object. When an individual fantasy calls for a custom-made automobile, the best thing the manufacturer can do is to take an assembly line engine and an assembly-line chassis and to modify a few of their external characteristics, by adding decorative features or accessories connected to the automobile on the outside as an essential technical object: only non-essential objects can be custom-made, because they are contingent.

The type of relations between these nonessential aspects and the true nature of the technical type is negative: the more a car must answer the critical demands of the user, the more its essential characteristics are encumbered by an external constraint; the body-work becomes weighed down with accessories [and] the shape no longer approximates stream-lined structures. The *custom-made* feature is not only non-essential, but works against the essence of the technical being, like a dead weight imposed on it from outside. The centre of gravity of the car is raised and its bulk increases.

However, it is not enough to affirm that the evolution of the technical object occurs because of a transition from an analytical order to a synthetic order that conditioned the transition from artisanal production to industrial production: even if this evolution is necessary, it is not automatic, and it is appropriate to investigate the causes of this progressive movement. These causes essentially reside in the imperfection of the abstract technical object. Because of its analytical character, this object uses more material and needs more construction work; while it is simpler logically, it is more complicated technically, because it is made from a bridging of several complete systems. It is more fragile than the concrete technical object, because, in the case of a break-down of the system, the relative isolation of each system constituting a functioning sub-assembly threatens the preservation of the other systems. So, in an internal combustion engine cooling could be carried out by an entirely autonomous sub-assembly; if the sub-assembly stops working, the engine can be ruined; if, on the other hand, cooling is the effect of the interdependent working of the ensemble, the functioning involves cooling; in this sense, an air-cooled engine is more concrete than an engine cooled by water: thermal infrared radiation and convection are effects that cannot be prevented: they are required by the functioning of the engine; cooling by water is semi-concrete; if it is entirely effected by thermo-siphon,* it would be almost as concrete as direct cooling by air; but the use of a water-pump that receives its energy from the engine by means of a drive-belt makes this type of cooling system more abstract in character; we could say that water-cooling is concrete as a security system (the presence of water makes possible an arbitrary cooling for a few minutes because of the absorption of calorific energy by vaporization if transmission from engine to pump is faulty); but in normal functioning this system is abstract; moreover, an element of abstraction still remains in the form of a possibility that there may be no water in the cooling circuit. Likewise, ignition by current transformer and storage battery is more abstract than magneto-ignition, and this in turn is more abstract than ignition by air-compression and fuel-injection used in Diesel engines. In this sense it could be said that an engine with a magnetic fly-wheel and air cooling is more concrete than an engine in an ordinary car; in it every unit plays many roles; it is not surprising that the motor-scooter is the fruit of the work of an engineer whose specialty is aviation; whereas the automobile can retain residues of abstraction (water-cooling, ignition by battery and current transformer), aviation has to produce technical objects of the most concrete sort in order to increase functional dependability and to reduce dead weight.

So, there is a convergence of economic constraints (the diminution of the quantity of raw material, of work, and of energy-consumption during use) and of purely technical requirements: the object ought not to be self-destructive, [and] it should remain in stable functioning for as long as possible. It seems that of these two kinds of causes,

economic and purely technical, the second predominates in technical evolution; indeed, economic causes are found in every domain; now, domains in which technical conditions prevail over economic conditions (aviation, war material) are the site of most active progress. Economic causes, then, are not pure; they involve a diffuse network of motivations and preferences which lessen and even reverse them (the taste for luxury, the desire for novelty that is so evident among consumers, and commercial advertising), to such an extent that certain tendencies towards complication come to light in domains where the technical object is known through social myths and opinion-fads and not appreciated for itself; for example, certain car manufacturers offer as an improvement the use of a superabundance of automatisms in accessories or a systematic recourse to power-steering* even when direct steering in no way exceeds the driver's strength: some of them go so far as to use the suppression of direct means such starting up the car with a crank-handle as a sales pitch and proof of improvement, even though the result is to make the functioning more analytical by making it depend on the use of electrical energy in the storage batteries; technically, there is a complication here, when the manufacturer presents this suppression as a simplification proving the modern character of the car, and rejecting into the past the stereotypical, indeed unpleasant, image of the difficult start. This casts nuances of ridicule on the other cars—those that have a starting-handle—because they are made to seem in some way old-fashioned and rejected into the past by a sales gimmick. The automobile, a technical object charged with psychic and social inferences, is not suitable for technical progress: progress in the automobile comes from neighboring domains, such as aviation, shipping, and transport trucks.

The specific evolution of technical objects does not happen in an absolutely continuous way, nor in a discontinuous way either: it includes stages that are defined by the fact that they bring into being successive systems of coherence; between the stages that mark a structural reorganization there can be an evolution of a continuous kind; it results from improvements in detail resulting from what use reveals, and from the production of raw materials or from the attachment of better adapted devices; thus, over the past thirty years the automobile engine has been improving because of the use of metals that are better adapted to the conditions of utilization, because of increased compression ratios resulting from research into fuels, and because of the study of the precise shape of cylinders and piston-heads in relation with the phenomenon of detonation.* The problem of achieving combustion without detonation can only be resolved by a scientific kind of research into the cause of the explosive wave within a petrol mixture at different pressures and temperatures, with different volumes and from set points of ignition. But an attempt such as this does not lead directly to applications: experimental work still has to be done, and there is an appropriate technicity for this slow trudging towards improvement. Reforms in structure that allow the technical object to reveal its own specific character constitute what is essential to the becoming of this object; even if the sciences made no progress during a certain period of time, the progress of the technical object towards specificity could continue to occur; the reason for this progress is none other than the way in which the object itself is affected and conditioned in its functioning and in the responses of its functioning to utilization.; the technical object , the result of an abstract travail in the organization of sub-assemblies, is the theatre of a number of relations of reciprocal causality.

These relations are what make it possible for the object, starting from certain limits in conditions of utilization, to discover obstacles within its own operation: *in the incompatibilities arising from the gradual saturation of the system of sub-assemblies there resides an interplay of limits, and the overcoming of this obstacle constitutes progress*[2]; but because of its very nature this overcoming of an obstacle can only be arrived at by a leap, by a modification of the internal distribution of functions, a rearrangement of their system; what was an obstacle should become a means of achievement. This is the case in the evolution of the electronic tube, of which the most common kind is the radio valve. Internal obstacles preventing the proper functioning of the triode led to structural improvements which resulted in the current series of valves. One of the most cumbersome phenomena in the triode was the critical mutual capacity within the system formed by the control grid and the anode; this capacity in fact created a capacitive coupling between the two electrodes, and it was impossible to increase significantly the size of these electrodes without the risk of seeing an initiation of self-oscillation; this unavoidable internal coupling had to be compensated for by external assembly procedures, particularly through a neutralizing effected by the use of an assembly of symmetrical tubes with an inter-connected anode-grid coupling.

To resolve the difficulty instead of evading it, an electrostatic shroud was introduced into the interior of the electrode between the control grid and the anode. Now, this addition does more than merely providing the advantage afforded by an electric screen. The screen cannot simply perform the decoupling function for which it was intended: when it is placed in the space between the grid and the anode, its difference in potential (in relation to the grid and in relation to the anode) causes it to act as a grid relative to the anode and as an anode relative to the grid. Its potential must be made higher than that of the grid and lower than that of the anode; without this condition, there is no transfer of electrons or else electrons move to the screen and not to the anode. So, the screen plays its part in the transfer of electrons from grid to anode; the screen is itself a grid and an anode; those two paired functions are not obtained intentionally; they are a self-imposing extra because of the character of the system the technical object presents. For the screen to be introduced into the triode without upsetting its functioning it has to perform, along with its electrostatic function, certain other functions relating to the electrons in transit. Considered as a simple electronic shroud, it could be raised to any voltage whatever, as long as the voltage is continuous; but then it would interfere with the dynamic functioning of the triode. It necessarily becomes an acceleration grid for the flux of electrons and plays a positive role in the dynamic functioning: it greatly increases internal resistance and, consequently, if the coefficient of amplification is carried to a determined voltage, it is defined by the exact position it occupies in the grid-anode space. The tetrode is therefore no longer only a triode lacking electrostatic coupling between the anode and the control grid; the tetrode is a steeply curved electronic tube that makes possible a voltage increase of about 200, instead of 30 or 40 for the triode.

This discovery, nevertheless, entailed a drawback: in the tetrode, the phenomenon of secondary emission of electrons by the anode proved cumbersome, and tended to send back to the screen all the electrons coming from the cathode and bypassing the control grid (primary electrons); for this reason Tellegen introduced a new

*See Appendix. All asterisks throughout the text refer to the Appendix.

[2] These are the conditions of the individuation of a system.

screen between the first screen and the anode: this large meshed grid when taken to negative potential in relation to anode and screen (generally the potential of the cathode or an even more negative potential) does not prevent the arrival at the anode of accelerated electrons from the cathode, but acts as a negatively polarized control grid and prevents the return of secondary electrons in the opposite direction. In this way, the pentode is the outcome of the cathode, in the sense that it comprises a supplementary control grid with fixed potential which completes the dynamic functioning scheme; however, the same irreversibility effect can be got by the concentration of the flux of electrons in beams; if the bars of the accelerating grid-screen are placed in the shadow of the bars of the command-grid, the phenomenon of secondary emission becomes greatly reduced. Furthermore, in the course of functioning, variation in capacity between cathode and grid-screen becomes very weak (0.2 ufd instead of 1.8 ufd), which practically suppresses all frequency drift when the tube is used in a circuit that generates oscillations. Consequently, it could be said that the functioning scheme of the tetrode is not perfectly complete in itself, if we conceive of the screen as a simple electrostatic shroud--that is, as an enclosed space kept at any constant voltage; such a definition would be too broad, too open; it requires a multiple functional incorporation of the screen with the electronic tube, which is brought about by reducing the margin of indeterminacy of the continuous voltage to be applied to screen (to make it an accelerator) and by its position in the grid-anode space; a first reduction consists in specifying that the continuous voltage should be intermediate between the grid voltage and the anode voltage; then, one gets a structure that is stable relative to the acceleration of primary electrons, but which remains relatively unstable relative to the trajectory of secondary electrons coming from the anode. This structure is still too open, too abstract; it can be closed so as to make it correspond to a necessary and stable functioning, either by means of a supplementary structure—suppressant grid or third grid—or by a greater precision in the placing of the grid-screen relative to the other elements, by aligning its bars with those of the control grid. It should be pointed out that the adding of a third grid is equivalent to the adding of a greater degree of determination to the position of the grid-screen: there is a reversibility between the functional character of the determinations of structures already existing by their reciprocal causality and the functional character of a supplementary structure; to close by a supplementary determination the reciprocal system of causality in extant structures is equivalent to adding a new structure that is especially designed to perform a specific function. There is a reversibility of function and structure in the technical object; an over-determination of the system in the speed of their functioning makes the technical object more concrete by stabilizing the functioning without the addition of a new structure. A tetrode with directed beams is the equivalent of a pentode; it is even superior in its function as amplifier of the power of acoustic frequencies, because it produces a lower level of distortion. The adjunction of a supplementary structure is not a real progress for the technical object unless that structure is concretely incorporated into the ensemble of the dynamic functioning systems; for this reason, we shall say that the tetrode with directed beams is more concrete than the pentode.

We must not confuse an increase in the concrete character of the technical object with an extension of the possibilities of the technical object resulting from a complication of its structure; for example, a twin-grid valve (that allows for the separate

action on two mutually independent control grids in a single cathode-anode space) is no more concrete than a triode; it is of the same order of the triode, and could be replaced by two independent triodes whose anodes and cathodes would be united externally but whose control-grids would be left independent. By contrast, the beam-directed tetrode is more fully evolved than the Lee de Forest triode, in that it is the realization of the development, the improvement of the original plan for the modulation of a flux of electrons through fixed or variable electric fields.

The original triode has a greater degree of indeterminacy than modern electric tubes, because interactions between structural elements during functioning are not defined, with one single exception, namely, the modulating function of the electric field produced by the control grid. The successive precisions and closures applied to this system transform into stable functions the disadvantages that arise of their own accord in the course of the functioning: in the necessity for the negative polarization of the grid to counteract heating and secondary emission lies the possibility of dividing the primitive grid into control grid and accelerating grid; in a tube that has an accelerating grid, the negative polarization of the control grid can be reduced to a few volts, to one volt in certain cases; the control grid becomes almost entirely a control grid; its function is more effective, and the slope of the tube increases. The control grid is brought closer to cathode; on the other hand, the second grid, the screen, is moved further away and is positioned at approximately an equal distance from the anode and the cathode. At the same time, the functioning becomes more precise; the dynamic system shuts down as an axiomatic is saturated. It used to be possible to regulate the slope of the primary triodes by potentiometric variation of the heating supply of the cathode, acting on the density of the flux of electrons; this possibility is hardly usable any longer with pentodes that have a steep slope, whose characteristics would be profoundly altered by an appreciable variation of the heating supply.

It surely seems contradictory to affirm that the evolution of the technical object both depends on a process of differentiation (the control grid of the triode dividing into three grids in the pentode) and on a process of concretization, with each structural element performing several functions instead of just one; but in fact these two processes are tied one to the other; differentiation is possible because this very differentiation allows for an integration into the functioning of the ensemble—and this in a manner conscious and calculated with a view to the necessary result—of the correlative effects of the overall functioning which were only partially corrected by palliative measures unconnected with the performance of the principal function.

A similar kind of evolution is noticeable in the change between the Crookes tube and the Coolidge tube; the former is not only less effective than the latter, it is also less stable in its functioning, and more complex; indeed, the Crookes tube uses cathode-anode voltage to separate molecules or atoms of mono-atomic gas into positive ions and electrons and then to accelerate these electrons and give them a critical kinetic energy before collision with the anticathode; in the Coolidge tube, on the other hand, the function of producing electrons is dissociated from that of accelerating electrons already produced; the production is caused by a thermoelectric effect (which is improperly called thermoionic, no doubt because it replaces the production of electrons by ionization) and the acceleration takes place later; in this way, the functions are purified by their dissociation and their corresponding structures are at the same time more distinct and

more elaborate; the hot cathode of the Coolidge tube is more elaborate from the point of view of structure and function than the Crookes tube; still, looked at from the electrostatic point of view, it is also perfectly a cathode; it is all the more so because it comprises a rather narrowly localized area for generating thermo-electrons and because the form of the surface of the cathode surrounding the filament insures an electrostatic gradient that makes possible a focusing of electrons in a narrow beam falling on the anode (of a few square millimeters in area in current tubes); in the Crookes tube, on the other hand, the area for generating of electrons is not narrowly enough defined to make possible a really effective focusing of the beam and, so, to obtain a source of X-rays close to an ideal punctuality.

Besides, the presence of ionizable gas in the Crookes tube not only presented the problem of instability (the hardening of the tube by the fixing of molecules on the electrode; the need for arranging locks to reintroduce gas into the tube); this presence of gas also caused an essential disadvantage: gas molecules presented an obstacle to already produced electrons in the course of their acceleration in the electric field between cathode and abode; this disadvantage is a typical example of the kinds of functional antagonism that come into play in the processes of an abstract technical object: the very gas that is necessary for the production of electrons to accelerate is an obstacle to their acceleration. This disadvantage disappears in the Coolidge tube, which is a high vacuum tube. It disappears because of the fact that the groups of synergetic functions are allocated to specific structures; by this distribution, each structure gains a greater functional capacity and an improved structural precision. This is so in the case of the cathode, which instead of being a simple spherical or hemispherical metal cap [*calotte*] becomes an ensemble made of a parabolic bowl [*cuvette*] at the centre of which there is a filament producing thermo-electrons; the anode, which in the Crookes tube had any position in relation to the cathode, becomes geometrically identifiable with the anticathode of yore; the new anode-anticathode plays two synergetic roles: in the first case, it produces a difference in potential relative to the cathode (the anode role); in the second, it constitutes an obstacle against which accelerated electrons collide as a result of a drop in potential, transforming their kinetic energy to light energy of a very short wave-length.

These two functions are synergetic because electrons have acquired maximum kinetic energy only after undergoing an entire drop in potential in the electric field; therefore, all at once, at this moment and place, it is possible to draw from them the greatest possible amount of electromagnetic energy by suddenly stopping them. Lastly, the new anode-anticathode plays a role in the evacuation of the heat produced (caused by inefficiency in the transformation of kinetic energy of electrons into electromagnetic energy, about 1%), and this new function is performed in perfect concordance with the two preceding functions: a plate of hard-to-fuse metal such as tungsten is embedded in the large beveled copper bar that forms the anode-anticathode at the point of impact of the beam of electrons; the heat developed on this plate is conducted to the outside of the tube by the copper bar, which is extended to the outside by cooling ribs.

There is a synergy of the three functions because the electric characteristics of the copper bar, a good conductor of electricity, are on a par with the thermal properties of the same bar, a good conductor of heat; besides, the beveled section of the copper bar is equally suited to its function as target-obstacle (anode), its function in accelerating

electrons (anode), and its function in the evacuation of the heat produced. We could say that in these conditions the Coolidge tube is at once a simplified and concretized Crookes tube, in which each structure performs a variety of synergetic functions. The imperfection of the Crookes tube, its abstract and artisanal character, that requires frequent adjustments as it functions, arose from the antagonism of functions performed by the rarified gas; this gas is suppressed in the Coolidge tube. Its indistinct structure corresponding to ionization is entirely replaced by the new thermoelectric characteristic of the cathode, which is perfectly distinct.

Thus, these two examples tend to show that differentiation goes in the same direction as the condensation of multiple functions on the same structure, because the differentiation of structures in the core of a system of reciprocal causalities allows for the suppression (by integration into the functioning) of secondary effects that formerly were obstacles. The specialization of each structure is a specialization of positive, functional, synthetic unity, free of unlooked-for secondary effects that amortize this functioning; the technical object progresses by interior redistribution of functions into compatible units, eliminating chance or the antagonism of initial distribution; specialization does not occur *function by function* but *synergy by synergy;* it is the synergetic group of functions and not the individual function constitutes the real sub-assembly in the technical object. It is because of this search for synergies that the concretization of the technical object can result in an aspect of simplification; the concrete technical object is one that is no longer in conflict with itself, one in which no secondary effect compromises the functioning of the whole, nor is it omitted from that functioning. In this way and for this reason, in a technical object that has become concrete perhaps a function can be performed by a number of synergistically associated structures, whereas in the primitive and abstract technical object each structure is designed to perform a specific function, and generally only one. The essence of the concretization of a technical object is the organizing of functional sub-assemblies in the total functioning; starting with this principle, we can understand how the redistribution of functions is brought about in the network of different structures, in abstract as much as in concrete objects: each structure performs a number of functions; but in the abstract technical object each structure performs only one essential and positive function that is integrated into the functioning of the ensemble: in the concrete technical object all functions performed by the structure are positive, essential, and integrated into the function of the ensemble; the marginal consequences of the functioning that are eliminated or attenuated by correctives in the abstract object become positive stages or aspects in the in the concrete object; the functioning scheme incorporates the marginal aspects; the consequences that were uninteresting or harmful become functional links.

This progress assumes that each structure is consciously endowed by its constructor with characteristics that correspond to all the elements of its functioning, as if the artificial object differed in no way from a physical system studied in all knowable aspects of energy exchange and of physical and chemical transformations; in the concrete object each piece is no longer merely a thing essentially designed to perform a function willed by the constructor; rather, it is part of a system in which a multitude of forces are exerted and in which effects are produced independent of the design plan. The concrete technical object is a physicochemical system in which mutual actions take place according to all the laws of science. The aim of technical design cannot be perfectly

realized in the construction of the object unless it is identified with universal scientific knowledge. It is important to insist that this latter knowledge must be universal because the fact that the technical object belongs to an artificial class of objects which meet a specific human need in no way limits or defines the type of physicochemical actions that can occur in that object or between that object and the outside world. The difference between the technical object and the physicochemical system studied as an object resides only in the imperfection of science; the scientific knowledge that provides a guide to predict the universality of mutual actions exerted in the technical system are affected by a certain imperfection; they do not make possible an absolute forecast of all effects with rigorous precision; this is why there remains a certain distance between the system of technical intentions corresponding to a defined end and the scientific system of the knowledge of causal interactions that that achieve this end; the technical object is never completely known; for this very reason, it is never completely concrete either, except in the rarest of chance occurrences. The ultimate assignment of functions to structures and the exact calculation of structures would be impossible, unless scientific knowledge of all possible phenomena in the technical object were fully acquired; since this is not the case, there remains a clear difference between the technical scheme of the object (comprising the representation of a human aim) and the scientific picture of the phenomena to which it gives rise (comprising only schemes of efficient causality, whether mutual or recurrent).

The concretization of technical objects is conditioned by the narrowing of the gap separating the sciences of technics; the original artisanal phase is characterized by a weak correlation between sciences and technics, while the industrial phase is characterized by a high correlation. The industrial construction of a specific technical object is possible once the technical object has become concrete, which means that it is understood in an almost identical manner from the point of view of the constructive plan and the scientific outlook. This explains why some objects could have been constructed in an industrial way long before others; a winch, a hoist, pulley-systems, a hydraulic press are all technical objects in which such phenomena as friction, charging, electro-dynamic induction, and thermal and chemical exchanges can be ignored in the majority of cases without causing the destruction of the object or a poor functioning; classical rational mechanics makes possible a scientific understanding of the principal phenomena that characterize the functioning of the objects that are called simple machines: however, it would have been impossible in the seventeenth century to construct industrially a gas-run centrifuge pump or a thermal engine. The first thermal engine to be constructed industrially, Newcommon's, used depression only, and the reason for this was the phenomenon of vapor condensation under cooling influences was scientifically known. Likewise, electrostatic machines have remained artisanal almost to our own day because, although the phenomena of the production and transport of charges by dielectrics and the flow of these charges by Corona effect have been qualitatively known since the eighteenth century at least, they have never been the object of very rigorous scientific studies; after the Wimshurst machine, the Van de Graaf generator itself retains something of the artisanal, despite its great size and its increased power.

III.—THE RHYTHM OF TECHNICAL PROGRESS; CONTINUOUS AND MINOR IMPROVEMENT, DISCONTINUOUS AND MAJOR IMPROVEMENT

So, essentially it is the discovery of functional synergies that characterizes progress in the development of the technical object. It is appropriate then that we should ask ourselves if this discovery is made all at once or in a continuous manner. Insofar as the reorganization of structures affects functioning, it happens suddenly, but can involve many successive steps; so, the Coolidge tube could not have been conceived before Fleming's discovery of the production of electrons by a heated metal; but the Coolidge tube with its static anode-anticathode is not necessarily the final version of the tube that produces X-rays or Gamma-rays. It is open to improvement and can be adapted to more particular uses. For example, an important improvement, one that allows for a discovery of a source of X-rays closer to the ideal geometric point, consisted in the use of an anode in the form of a heavy plate mounted on an axis, in the tube: this plate can be set in motion by a magnetic field created by an inductor placed outside the tube and in relation to which the plate is a rotor comprising an armature. The region of impact of electrons becomes a circular line close to the edge of the copper plate, and because of this presents very great possibilities of thermal dissipation; nevertheless, statistically and geometrically, the place where the impact occurs is fixed in relation to cathode and tube: the beam of X-rays therefore derives from a geometrically fixed centre, although the anticathode scrolls at high speed to the fixed focal point. Tubes with a rotating anode allow for an increase in power without increasing the size of area of impact or allow for a reduction of the size of the area of impact without a diminution in power; now, this rotating anode also fulfils the function of speeding and stopping electrons as efficiently as a fixed anode; it is more efficient in the business of heat-evacuation, and this permits the improvement of the optic characteristics of the tube for a given power.

Should we then consider the invention of the rotating anode as providing the Coolidge tube with a structural concretization? – No, because it the special role of lessening a disadvantage that could not be converted to a positive aspect of the functioning of the whole. The disadvantage of the Coolidge tube, the residual aspect of antagonism continuing in its functioning, is its low efficiency in converting kinetic energy to electromagnetic radiation; without doubt, this low efficiency does not constitute a direct antagonism between functions, but in practice it becomes a real antagonism; if the melting temperature of the tungsten plate and of the copper bar were to be raised indefinitely, it would be possible to bring to a very precise focus a very strong beam of very fast electrons; but since in fact the melting point of tungsten is fairly quickly reached, we find that this low efficiency is a limitation, which produces a great amount of heat, and it is necessary to decide to sacrifice the fineness of the beam or the density of the flow of electrons or the speed of the electrons; this means that we must sacrifice the punctuality of the source of X-rays, the quantity of electromagnetic energy radiated, or the penetration of the resulting X-rays. If only a means had been found to increase the efficiency of the transformation of energy that occurs on the anticathode slab, all characteristics of the Coolidge tube would have been improved, by suppressing or diminishing the most critical of the antagonisms that subsist in this functioning. (A much weaker antagonism consists in the impossibility of rigorously focusing the beam because of the mutual repulsion of electrons affected by electrical charges of the same sign; it could be compensated for by means of beam-focusing devices comparable to those of cathode type oscilloscopes, or of electrostatic lenses, or of the electromagnetics of

electron microscopes.) The rotating anode makes it possible to reduce the consequences of the antagonism between sharpness and power, and between optic and electronic characteristics.

There are two kinds of improvement, therefore: those that modify the division of functions, increasing in an essential way the synergy of functioning, and those that, without modifying the division in question, diminish the harmful consequences of residual antagonisms; the following belong to this order of minor improvements: a more regular system of lubrication in an engine, the utilization of self-lubricating bearings, the use of metals of higher resistance, the use of more solid assemblies. So, in electronic tubes, the discovery of the increased transmitting power of certain oxides or of metals such as thorium has made possible the construction of oxide cathodes that operate at a lower temperature and absorb less heat energy for the same density of electronic flow. Important as this may be in practice, it remains minor and it is suitable only for certain kinds of electronic tubes because of the relative fragility of the oxide covering. The rotating anode of the high powered Coolidge tube is also a minor improvement; it provisionally replaces a major improvement which would consist in the discovery of a more highly efficient energy transformation, making it possible to reduce to a few hundred watts the power used to accelerate the electrons, where present-day radiography tubes need many kilowatts.

In this sense, one can say that minor improvements are harmful to major improvements, because they can conceal the real imperfections of a technical object by using non-essential devices, incompletely integrated into the functioning of the whole, to compensate for real antagonisms; the dangers attendant on abstraction are evident anew in the case of minor improvements; so, the Coolidge tube with its rotating anode is less concrete than a tube with static cooling provided by a copper bar and fins in the air; if, for whatever reason, the rotation of the anode stops while the tube is functioning, the point of the anode receiving the concentrated beam of electrons begins instantaneously to melt and the whole tube is damaged; this analytic character of the functioning then makes necessary another species of correctives, security systems obtained by conditioning one functioning by means of another functioning; in the case analyzed, it is necessary that the generator of anode supply should not function unless the anode is already turning; a relay controls the application of voltage to the transformer supplying the anode supply for the passage of current to the inductor of the anode motor; but this subordination does not entirely reduce the analytic distance introduced by the rotating anode device; the current can pass into the inductor without an effective turning of the anode, for example, as a result of axis deterioration; the relay can also remain switched on even if the inductor is not live.

An extreme complication and an extreme improvement of ancillary systems of security or of compensation can only tend towards the equivalent of the concrete in a technical object without either attaining it or even preparing for it, because the road taken is not the road of concretization. The road of minor improvements is one of detours; useful as detours are in cases of practical use, they hardly promote the evolution of the technical object. By concealing the real schematic essence of each technical object under a pile of complex palliatives, minor improvements promote a false understanding of the continuity of progress in technical objects, by diminishing the value and the sense of urgency of essential transformations. For this reason, continuous minor improvements

provide no clear boundary with regard to the false renewal that commerce requires so that it can present a recent object as superior to earlier ones. Minor improvements can be so non-essential as to be concealed by the cyclic rhythm of forms that fashion superimposes on the essential lines of utilitarian objects.

It is not enough to say then that the technical object is one that has a specific genesis proceeding from the abstract to the concrete; once again, it must be stated that this genesis is achieved by essential and discontinuous improvements that bring about modifications in the internal scheme of the technical object, and do so in leaps and not along a continuous line. This does not mean that the development of the technical object is brought about by chance and that it is independent of any assignable meaning; on the contrary, it is minor improvements that to some extent happen by chance, obscuring by their non-coordinated proliferation the pure lines of the essential technical object. The real improvement stages in the technical object are achieved by mutations, but by directed mutations: the Crookes tube contains in potential the Coolidge tube, because the intention which is organized and stabilized and purified in the Coolidge tube pre-existed in the Crookes tube, in a confused but real state. Many abandoned technical objects are incomplete inventions that remain as an open potentiality and could be taken up once more, extended in another field, in accordance with their underlying intent, their technical essence.

IV. – THE ABSOLUTE ORIGINS OF A TECHNICAL LINEAGE

Like every evolution, the evolution of technical objects raises the problem of absolute origins: to what first term can we trace the birth of a specific technical reality? Before the pentode and the tetrode there had been the Lee de Forest triode; before the Lee de Forest triode, there had been the diode. But what had there been before the diode? Is the diode an absolute origin? Not completely; without doubt, thermoelectric emission was then unknown but phenomena of the charge transport in space by an electric field had long been known: electrolysis had been known for a century, and the gas ionization for many decades; thermionic emission is necessary for the diode as a technical scheme, because the diode would not be a diode if the transport of electric charges were reversible; in normal conditions there is no such reversibility, because one of the electrodes is hot and consequently emissive, and the other cold and consequently non-emissive; what makes the diode essentially a diode, a two-way valve, is that the hot electrode can be almost equally either cathode or anode, while the cold electrode can only be an anode, as it cannot emit electrons; it can only attract them, if it is positive, but it cannot emit them, even if it is negative in relation to another electrode. The result of this is that if external voltages are applied to the electrodes, a current will pass through because of the thermionic effect if the cathode is negative in relation to the anode, whereas no current will pass through if the hot electrode is positive in relation to the cold electrode. This discovery of a condition of functional dissymmetry between electrodes is what constitutes the diode and not, strictly speaking, the transport of electric charges across a vacuum by means of an electric field; experiments with the ionization of monatomic gases had earlier shown that free electrons can move about in an electric field; but this phenomenon is reversible and not polarized; if the rarified gas tube is turned

around, the positive pole and the luminous rings change sides in relation to the tube, but their position remains unchanged in relation to the direction of current coming from the generator. The diode is made from the association of this reversible phenomenon of the transport of electric charges through a field and from the condition of irreversibility created by the fact that the production of transportable electric currents is the production of a single kind of electric charges (negative only) and by only one of two electrodes, the hot electrode; the diode is a vacuum tube in which there is a hot electrode and a cold electrode, between which an electric field is created. Here surely we have an *absolute beginning*, residing in the association of this condition of electrode irreversibility and in the phenomenon of the transport of electric charges across a vacuum: *technical essence* has been created. The diode is an asymmetric conductance.

However, it must be noted that this essence is broader than the definition of the Fleming valve; many other processes creating asymmetric conductance have been discovered; the contact of galena with a metal, of copper with copper oxide, of selenium with another metal, of germanium with a tungsten point, as well as of silicon with a metal point are all examples of asymmetric conductance. Finally, a photoelectric cell could be considered a diode, because the photoelectrons behave like thermo-electrons in the vacuum of the cell (in the case of the vacuum cell and also of the gas cell, but the phenomenon is complicated by the emission of secondary electrons that become attached to the photoelectrons). Should the word diode therefore be restricted to the Fleming valve? Technically, the Fleming valve could be replaced in a number of applications by germanium diodes (for weak intensities and high frequencies) or by selenium or copper oxide rectifiers, for applications of low frequency and great intensity. But use does not provide good criteria: the Fleming valve could also be replaced by a rotating transformer,* which is a technical object using an essential scheme that is entirely different from that of the diode. In fact, the thermo-electronic diode constitutes a clearly defined type, with its own historical existence; above this type there is a *pure functioning scheme* which is transposable into other structures, for example into those of imperfect conductors or semi-conductors; the functioning scheme is the same, to the extent that on a theoretical diagram a diode can be indicated by a sign (asymmetric conductance: *) which does not prejudge the kind of diode used, and gives complete freedom to the manufacturer. But the pure technical schema specifies a type of existence for the technical object understood in terms of its ideal function, which is different from the reality of the historical type; historically, the Fleming diode is closer to the Lee de Forest triode than to the germanium rectifier or to the copper oxide rectifier or the selenium and iron rectifier though these are indicated by the same schematic symbols and, in certain cases, perform the same functions, to the point of being replaceable by the Fleming diode. It is a fact that the whole essence of the Fleming valve is not contained in its feature as asymmetric conductance; it is also a device that produces and conducts that flow of electrons which can be slowed down or accelerated or deviated, and can be dispersed or concentrated, repelled or attracted; the technical object exists not only by virtue of the product of its functioning in external devices (an asymmetric conductance) but by virtue of phenomena of which it is itself the seat: for this reason it has a *fecundity*, a *non-saturation* that gives it posterity.

The original technical object could be thought of as a non-saturated system: the later improvements it undergoes act as developments towards the saturation of the system; from the outside, it is possible to believe that the technical object is being altered and is changing its structure rather than being improved. But it could be said that the technical object evolves by engendering a family: the primitive object is the ancestor of this family. An evolution of this sort could be called a *natural technical evolution*. In this sense, the gas engine is the forefather of the gasoline engine and the diesel engine; the Crookes tube is the ancestor of the Coolidge tube; the diode is an ancestor of the triode and of other multiple-electrode tubes.

At the beginning of each of these series, there is a defined act of invention; in one sense, the gas engine derives from the steam engine; the arrangement of its cylinder, piston, transmission system, and distribution by slide-valve and slots is similar to that of the steam engine; but it derives from the steam engine as the diode derives from the discharge tube through ionization in gases: besides, what was necessary was a new phenomenon, a system that existed neither in the steam engine nor the discharge tube: in the steam engine, the boiler producing gas under pressure and the heat source were outside the cylinder; in the gas engine, it is the cylinder itself, as combustion chamber, that becomes boiler and furnace: combustion takes place within the cylinder: it is an internal combustion; in the discharge tube, the electrodes were indifferent, the conductance remaining symmetrical; the discovery of the thermoelectric effect makes it possible to make a tube similar to the discharge tube in which the electrodes are polarized, thus rendering the conductance asymmetric. The beginning of a lineage of technical objects is marked by a synthetic act of invention that is basic to a *technical essence*.

Technical essence can be recognized by the fact that it remains stable throughout the evolutionary lineage, and not only stable, but also producing structures and functions through internal development and progressive saturation; this is why the technical essence of the internal combustion engine could become that of the diesel engine, by a supplementary concretization of functioning: in the preliminary combustion engine, the heating of the fuel mixture in the cylinder at the moment of compression is non-essential and even harmful, since it risks producing detonation instead of producing deflagration (progressive explosive wave combustion), which limits the ratio of admissible compression for a given kind of motor fuel; in the diesel engine, on the other hand, this heating resulting from compression becomes essential and positive, because it causes the beginning of conflagration; this positive characteristic of the role of compression is obtained by means of a more precise fixing of the moment when carburetion should occur in the cycle: in the preliminary carburetor engine, carburetion can happen at any time before the introduction of the carbureted mixture into the cylinder; in the diesel engine, the carburetion must take place after the introduction and compression of pure air, free of carburant fumes, at the precise moment when the piston reaches the top dead point, because this introduction causes the beginning of deflagration (the beginning of the stroke time in the cycle) and cannot cause this unless it occurs at the moment when the air reaches its highest temperature, at the end of compression; for this reason, the introduction of the carburant into the air (carburetion) is charged with much more functional significance in the diesel engine than in the gasoline engine; it is integrated into a more structured and rigorous system , which allows the manufacturer less freedom and

the user less tolerance. The triode is also a more saturated system than the diode; in the diode, asymmetric conductance is limited solely by thermoelectronic emission; when the cathode-anode voltage is raised, the internal current progressively increases for a temperature determined by cathode, but reaches a certain ceiling (saturation current) which corresponds to the fact that all electrons emitted by the cathode are captured by the anode. For this reason, the only way to regulate the current crossing the diode is to vary the anode voltage; on the other hand, the triode is a system in which the current crossing the cathode-anode space can be made to vary on a continuous basis, without making any variation in cathode-anode voltage; the primitive property remains (variation of the current as a direct function of anode-cathode voltage) but it is doubled by a second possibility of variation, that which determines the voltage of the control grid; the function of variation, which originally adhered to anode voltage, now becomes a free and well defined individualized property, which adds an element to the system and consequently saturates it, because the regime of causalities includes an extra component; throughout the evolution of the technical object, the saturation of the system by segregation of functions is notable; in the pentode the current crossing the cathode-anode space becomes independent of anode voltage for values of anode voltage lying between a very low minimum and a high maximum defined by the possibility of thermal dissipation. This characteristic is stable enough to make possible the use of the pentode as a charge resistance in relaxation oscillators that are needed for the production of linear saw teeth for the horizontal sweep voltages in cathode-ray oscillographs; in this particular case, the screen voltage, the control grid voltage, and the voltage of the third grid (suppressor) are kept fixed. In the triode on the other hand, for a given voltage in the control grid, the anode current varies as a function of anode voltage: in this sense, the triode is still easily akin to a diode, whereas this is no longer true of the pentode in dynamic mode; this difference is due to the fact that in the triode the anode continues to play an ambiguous role dual role of an electrode capturing the electrons (a dynamic role) and of an electrode creating an electric field (a static role); as opposed to this, in the tetrode or the pentode, the maintenance of the electric field, regulating the flow of electrons, is assured by the grid screen, which plays the role of an electrostatic anode; the anode-plate plays a single role, that of capturer of electron; for this reason, the slope of the pentode can be much greater than that of the triode, because the function of maintaining the electrostatic field of acceleration is guaranteed without either variation or diminution (the screen is at a fixed potential), even when the anode voltage dips when there is an increase in current, because of the insertion of a load resistance in the anode circuit. We can say that the tetrode and the pentode eliminate the antagonism in the triode between the function of the acceleration of electrons by the anode and the function of harnessing electric charges conveyed by electrons accelerated by the same anode, a function that occasions a drop in anodic potential when load resistance is inserted, and it lessens the acceleration of electrons. From this point of view, the grid screen should be considered as an electrostatic anode of fixed voltage.

It is clear, then, that the tetrode and the pentode are definitely results of the development of the original diode system through saturation and synergetic concretization. The grid-screen concentrates in itself all the functions relative to the electrostatic field, functions that correspond to the conservation of a fixed potential; the control grid and the anode maintain no functions other than those that have to do with a

variable potential, which they can then fulfill in a greater measure (in the course of operation, the anode of a pentode used as a voltage amplifier can be raised to potentials between 30 and 300 volts in dynamic mode); the control grid captures fewer electrons than in a triode, and this makes it possible to treat the input impedance as very high: the control grid becomes more purely a control grid and is no longer subject to continuous current created by the capturing of electrons; it is more strictly an electrostatic structure. So, the pentode and the tetrode can be considered to be direct descendants of the triode, because they realize the development of its internal technical scheme through a reduction of incompatibilities by means of a redistribution of functions in synergetic subsystems. The subjacency and stability of the concrete scheme of organizing invention in successive developments constitute the unity and the distinction of a technical lineage.

Concretization gives the technical object an intermediate place between the natural object and its scientific representation. The abstract, or primitive, technical object is far from constituting a natural system; it is the translation into matter of an ensemble of scientific notions and principles that at a basic level are unconnected one with the other and are connected only by those of their consequences that converge for the production of a looked for result. This primitive technical object is not a physical natural system; it is the physical translation of an intellectual system. For this reason, it is an application or a bundle of applications; it is a consequence of knowledge, and can learn nothing; it cannot be inductively examined as a natural object, because it is nothing if not artificial.

On the other hand, the concrete technical object, that is to say the evolved technical object, approximates the mode of existence of natural objects, and tends to internal coherence, to the closing of the system of causes and effects that operate circularly inside its boundaries and, further, incorporates part of the natural world that intervenes as a condition of its functioning, and, thus, becomes part of the system of causes and effects. This object, by evolving, loses it artificial character: the essential artificiality of an object resides in the fact that man has to intervene in order to keep the object in existence by protecting it from the natural world by giving it status as well as existence. Artificiality is not a characteristic denoting the manufactured origin of the object as opposed to the productive spontaneity of nature: artificiality is something that is within the artificializing action of man, regardless of whether this action affects a natural object or an entirely fabricated object; a flower that is grown in a hot greenhouse and that can only produce petals (a double flower) without engendering a fruit, is the flower of an artificialized plant; man has diverted the functions of this plant from their coherent development, to the extent that it can no longer reproduce except by processes such as grafting, processes requiring human intervention. The artificialization of a natural object has results that are opposite to the results of technical concretization: the artificialized plant can exist only in the laboratory for vegetables that is the greenhouse, with its complex system of thermal and hydraulic controls. The initially coherent system of biological functioning has been opened up to functions that are independent of each other, and are related to each other only by the gardener's care; flowering has become pure, detached, and anomic flowering; the plant blooms until it is worn out and it produces no seeds. It loses its initial capacities to resist cold, drought, and exposure to the sun; the originally natural controls of the object are replaced by the artificial controls of the greenhouse. Artificialization is a process of abstraction in the object that has been rendered artificial.

By technical concretization, on the other hand, the originally artificial object comes more and more to resemble a natural object. In the beginning, this object had need of an external regulatory environment, the laboratory or the workshop, sometimes the factory; little by little, as it increases in concretization, it becomes capable of doing without the artificial environment, because its internal coherence increases and its functional systematic becomes closed by becoming organized. The concretized object is comparable to an object that is produced spontaneously; it becomes independent of the laboratory associated with it originally and dynamically incorporates it into itself in the set of its functions; its relation with other objects, whether technical or natural, becomes regulatory and makes possible the self-maintenance conditions of operation; this object is no longer isolated; it becomes associated with other objects, or it is self-sufficient, whereas at the beginning it was isolated and heteronomous.

The consequences this concretization are not only human and economic (for example, by warranting decentralization) but also intellectual: since the mode of existence of the concretized technical object is analogous to that of spontaneously produced natural objects, we can legitimately think of them as natural objects, which means that we can subject them to an inductive study. They are no longer simply the application of previous scientific principles. As they exist, they prove the viability and the stability of a certain structure that has the same status as a natural structure, though it can be schematically different from all natural structures. The study of the functioning systems of concrete technical objects is scientifically of value, because those objects are not derived from a single principle; they are evidence of a certain mode of functioning and of compatibility that exists in fact and that was constructed before being planned: this compatibility was not contained in each of the separate scientific principles that that played their part in the construction of the object; it was discovered empirically; for an investigation of this compatibility, we can turn towards the separate sciences in order to pose the problem of the correlation of their principles and found a science of correlations and transformations that would be a general technology or mechanology.

But for this technology to have meaning, it is necessary to avoid basing it on an improper assimilation of the technical object to the natural object and particularly to the living. Analogues or, rather, external resemblances should be rigorously banned: they have no meaning and can only mislead. Meditation on automata is unsafe because it risks being confined to a study of outer characteristics and so making a false assimilation. What alone count are exchanges of energy and information in the technical object or between the technical object and its milieu; outward aspects of behavior observed by a spectator are not objects of scientific study. And it would not even be right to found a separate science for the study of regulatory and control mechanisms on automata built to be automata: technology should take as its subject the universality of technical objects. In this respect, cybernetics is inadequate: it has the boundless merit of being the first inductive study of technical objects and of being accepted as a study of the middle ground between the specialized sciences; but to a great extent it has made its field of investigation too specialized, for it emerged from the study of a number of technical objects; it accepted at its starting point what technology should decline: a classification of technical objects that operates with reference to genera and species. There is no *species* of automata: there are only technical objects, with a functional organization that realizes various degrees of automatism.

What threatens to make the work of cybernetics to some degree useless as an interscientific study (though this is what Norbert Weiner defines as the goal of his research) is the basic postulate that living beings and self-regulated technical objects are identical. Now, the only thing we can say is that technical objects tend to concretize, whereas natural objects as living beings are concrete right from the start. The tendency to concretize should not be confused with the status of an entirely concrete existence. Any technical object has to some degree residual aspects of abstraction; one should not go to the extreme extent of speaking of technical objects as if they were natural objects. Technical objects should be studied in their evolution so as to abstract from it the process of concretization as a tendency; but one must not isolate the final product of technical evolution so that it can be defined as fully concrete; it is more concrete than its precedents, but it is artificial still. Instead of considering one class of technical beings, automata, we should follow the lines of concretization throughout the temporal evolution of technical objects; all mythology apart, this is the only way by which the link between the living being and the technical object has real meaning. If the finality were not thought out and brought to realization by the living, physical causality alone could not produce a positive and effective concretization.

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Gilbert Simondon. *On the Mode of Existence of Technical Objects*

FIRST PART

THE GENESIS AND EVOLUTION OF TECHNICAL OBJECTS

Chapter II

THE EVOLUTION OF TEHNICAL REALITY; THE ELEMENT, THE INDIVIDUAL, THE ENSEMBLE

1.—HYPERTELY AND SELF-CONDITIONING IN TECHNICAL EVOLUTION

The evolution of technical objects demonstrates hypertelic phenomena that give each technical object an exaggerated specialization and makes it adapt badly even to a slight change arising in the conditions of use or manufacture; the scheme that constitutes the essence of the technical object can in fact be adapted in two ways: first, it can be adapted to the *material and human conditions* of its production; each particular object can make the best possible use of the electrical, mechanical, or even chemical characteristics of the materials of which it is made; subsequently it can be adapted *to the task* for which it is made: so, a tire that is suitable for use in a cold country may not be at all suitable for a hot country, and vice versa; an airplane made for high altitudes may have difficulties when it needs to function for a short period at low altitude, and particularly when landing and taking off . The jet engine, whose principle of propulsion makes it better than the propeller engine at very high altitudes, does not work well at a very low altitude; the great speed attained by the jet plane becomes a crippling factor in terms of making contact with the ground; the reduction of the lifting surface coupled with the use of a jet engine makes it necessary to land at high speed (almost at the cruising speed of a propeller plane) and this creates the need for a very long landing strip.

Early airplanes, which could land in the open country, were functionally less over-adapted than modern planes. Functional over-adaptation goes so far as to culminate in schemes resembling the stages between symbiosis and parasitism in biology: some very fast small planes cannot easily take off unless they are carried by a larger plane that launches them into flight; others use rockets to increase the upward push. The transport glider is itself an example of a hypertelic technical object: it is nothing if not an air freighter or rather an air barge without a towing vessel, and in this it is different from the ordinary glider that, after a simple launching, can avail of aerial currents to stay in the air on its own. The autonomous glider is very well adapted to engineless flight, while the transport glider is merely one of two asymmetrical partners in a technical whole whose the other half is the towing vessel; for its part, the towing vessel is not well adapted because on its own it is not able to carry a load proportional to its power.

We can say therefore that there are two kinds of hypertely: one that is finely adaptable to clearly defined requirements, without involving the slightest fragmentation of the technical object or any loss of autonomy, the other that is consistent with a fragmentation of the technical object, as in the case of the division of a single original

technical being into towing unit and unit towed. The first case retains the autonomy of the object, whereas the second sacrifices it. A mixed case of hypertely is one involving an adaptation to the milieu like when the object needs a particular kind of milieu in order to work properly, because it is paired energetically with its milieu; the case is almost identical to that of the division into towing and towed units; for example, a clock that is synchronized by a circuit loses its capacity to function if it is transported from America to France, because of the difference in frequency (60Hertz and 50 Hertz respectively); an electric motor requires a circuit or a generator; a single-phased synchronous motor can be more satisfactorily adapted to a given milieu than a universal motor: within this milieu it works satisfactorily, but outside of that milieu it is worthless. A three-phase synchronous motor is even better adapted than a single-phase motor to functioning in a given type of circuit, but outside of that circuit it can no longer be used; by means of this limitation, it provides a more satisfactory functioning than that provided by a single-phase motor (a better control system, better output, very little wear, slight losses in hook-up lines).

Such an adaptation to the technical milieu is, in certain cases, of fundamental importance; for example, the utilization of three-phase alternative current is perfectly satisfactory for factory engines of whatever capacity. Nevertheless, until today day it has not been possible to use three-phase alternating current to drive electric trains. A transfer system must be used that connects and mutually adapts the DC engine of the locomotive to the network of three-phase AC high voltage transmission: this can be done either by having sub-stations supply continuous voltage to the feeders of overhead power cables or by using transformers and adapters on board the locomotive itself to supply the engine with continuous voltage even when the overhead cables are powered by AC voltage. Indeed, by being adapted energetically and in frequency to the energy-distributing network, the locomotive engine would have been forced to lose too large a part of its range of use. A synchronous or asynchronous engine does not provide a large amount of mechanical energy until it has already reached its working speed; now, this is excellent for a stationary machine such as a lathe or a drill that starts without a charge and only meets significant resistance after it has reached working speed, but this is not at all the case with the locomotive engine; the locomotive starts with full charge, with all the inertia of the train; when it functions at its working speed (if strictly speaking we can refer to the working speed of a locomotive) that is when it has least energy to supply; the engine of a locomotive should supply maximum energy in transitional stages, whether of acceleration or deceleration, for counter-current braking. This use with its many frequent adaptations to variations in speed is opposed to the reduction of the range of systems of utilization that characterizes adaptation to the technical milieu, as for example the factory with its multiphase circuit of constant frequency. This example of the traction engine helps us understand that there is of a double relationship which maintains the technical object, a relationship with the geographic milieu on the one hand and with the technical milieu on the other.

The technical object is at the point at which two milieus come together, and it ought to be integrated into both milieus at the same time. Nevertheless, since these two milieus are two worlds that are not part of the same system and are not necessarily completely compatible with each other, the technical object is determined in some way by human choice which tries to establish the best compromise possible between the two

worlds. The traction engine, in a sense, resembles a factory engine in that it receives its energy from high voltage, three-phase, alternating lines; in another sense, it is a device that expends its energy to tow a train from a stop to full speed and to a stop once again by decreasing rates of speed; it has to haul the train up ramps, around curves, and down slopes, maintaining the most constant speed possible in all of this. The traction engine does not only transform electric energy into mechanical energy; it applies it to a geographically varied world, being translated technically by the lie of the track, the varying resistance of the wind, and the resistance of the snow which the front of the locomotive pushes back and shoves aside. The traction engine responds to the line that powers it with a reaction that results from the geographical and meteorological structure of the world: there is an increase in the absorbed intensity and a decrease in line voltage when snow deepens, when the slope becomes steeper, and when lateral wind increases friction by pushing the flanges of the wheels against the rails. *The two worlds act on each other* through the traction engine. Contrary to this, a three-phase factory engine does not establish a reciprocal causal relationship of this sort between the technical world and the geographic world; its operation is almost totally confined within the technical world. This uniqueness of milieu explains why there is no need for a milieu of adaptation for the factory engine, whereas the traction engine has need of a milieu of adaptation constituted by repressors, placed in the sub-station or on the locomotive itself; all the factory engine needs by way of milieu of adaptation is a voltage-lowering transformer, which could be cancelled for high-powered engines but which is necessary in the case of engines of medium power, as a precautionary measure aimed at human users rather than as a real adapter of milieu.

Adaptation follows a different curve and has a different significance in the third case; in this case it cannot lead so directly to phenomena of hypertely and the mismatch resulting from hypertely. The necessity of adaptation not to a given milieu in the strict sense, but to the task of relating two milieus each of which is in evolution, limits adaptation and makes it more precise in terms of autonomy and concretization. That is genuine technical progress. In this way, the use of silicon sheet metal, which has a higher magnetic penetrability and a lower hysteresis than iron sheet metal has made it possible to reduce the volume and weight of traction engines and, at the same time, to increase their efficiency; a modification of this kind improves the function of mediation between the technical world and the geographic world, because a locomotive can have a lower centre of gravity as a result of placing its engines on the same level as the bogies; there is less inertia of the rotor, and this is important for quick braking. The use of silicon insulators has made possible a toleration of significant overheating without the risk of insulator deterioration, and this increases the possibilities of very high intensity to improve the engine torque at startup and the resisting torque at braking. Such modifications extend rather than restrict the field of use of traction engines. A silicon-insulated engine could be used without extra precautionary measures on a locomotive that has to climb very steep slopes or in a very hot country; the relational use increases; the same kind of improved engine can be used (in smaller sizes) as the braking system in trucks; in fact, the engine is adapted to the relational modality and not solely to the single type of relation that links the network to the geographic world to pull a train.

A parallel example of concretization is provided by the Guimbal turbine[1]; this turbine is immersed in the penstock that is connected to a very small generator contained in a crankcase filled with oil under pressure. Thus, the dam wall contains the whole electric factory in the penstock, since at ground level all that appears is the hut containing the oil reservoir and the measurement instruments. The water becomes multifunctional: it supplies the energy that activates the turbine and the generator, and it evacuates heat produced by the generator; the oil is also remarkably multifunctional: it lubricates the generator, insulates the coil, conducts heat from coil to crankcase, from which it is evacuated by the water; finally, it prevents the seepage of water into the crankcase through the glands of the axis, since the pressure of the oil inside the crankcase is greater than the pressure of the water outside the crankcase. This high pressure is itself multifunctional; it causes permanent greasing under pressure of the bearings at the same time as it prevents seepage of water if the bearings are not watertight. At this point, it should be noted that it is thanks to multi-functionality that this concretization and this rational adaptation have become possible. Before Guimbal's invention, no one would even think of placing the generator in the penstock containing the turbine, because, even if all problems of water-tightness and insulation could be thought of as solved, the generator was too big to be placed in a pipe; the mode used to solve problems regarding water-tightness and electric insulation is what makes possible the introduction of the generator into the pipe by allowing for an excellent cooling by means of both oil and water. One might even go so far as to say that the introduction of the generator into the pipe *is* itself *made possible* by allowing for drastic cooling by water at the same time. Now, the great effectiveness of the cooling makes for a significant reduction in size for the same power. If the Guimbal generator were used at full power in the air, it would quickly be ruined by heat, whereas it shows no appreciable heat in its double concentric bath of oil and water, each of which is energetically pulsated, the oil by the rotation movement of the generator and the water by the turbulence of the turbine. Concretization is here determined by an invention *which assumes that the problem is solved*; indeed, this particular concretization is possible because of the new conditions established by concretization; the only milieu that tolerates non-hypertelic adaptation is the milieu established by the adaptation itself; in this case, the act of adaptation is not merely an act of adaptation in the sense we give the word when we define adaptation in relation to a milieu that has been already established before the process of adaptation.

Adaptation-concretization is a process that causes the birth of a milieu instead of being caused by an already established milieu; it is caused by a milieu that had merely virtual existence before the invention; the invention occurs because a jump has been made and justified by the relationship it institutes within the milieu it establishes: the condition of the possibility of this turbo-generator pairing is its realization; it cannot be geometrically situated within the water-pipe, unless there is some way physically of effecting thermal changes that make possible a reduction of dimensions. One could say that the reifying invention brings into being a techno-geographic milieu (in this case, oil and water in turbulence), which is a condition for the possible functioning of the technical object. *Therefore, the technical object is the condition of itself as a condition for the existence of this mixed milieu,* which is at once technical and geographical. This

[1] These turbines are of the same kind as those that equip *bulb groups* in the new French tide-powered factories. They are reversible and can be used to pump water at low tide with a small expenditure of energy.

phenomenon of self-conditioning defines the principle by which it is possible to develop technical objects that are without tendency to hypertely and then to mismatch; hypertely arises when adaptation relates to a datum that existed before the process of adaptation; indeed, an adaptation of this kind has as its goal conditions that always outstrip it, because it does not react to them and because it fails in its turn to condition them.

The evolution of technical objects can become progress only to the extent that these technical objects are free to evolve and are not subject to any necessity in the direction of a fatal hypertely. For this to be possible, the evolution of technical objects has to be constructive, that is to say it has to lead to the establishment of that third techno-graphical milieu, where every modification is self-conditioned. What is in question here is not progress conceived as a step forward in a predetermined direction, nor as a humanizing of nature; that process could equally well be thought of as a naturalization of man; indeed, between man and nature there develops a techno-geographic milieu whose existence is not possible except through man's intelligence: the self-conditioning of a scheme by the result of its functioning requires the use of an inventive function of anticipation that is discoverable neither in nature nor in already constituted technical objects; it takes the work of a lifetime to jump past established reality and its current systematic to reach new forms that can only endure because they exist all together as a continuous system; when a new organ appears in the progressive series, it can only endure if it achieves a systematic and multi-functional convergence. The organ is its own condition. In a similar way the geographical world and the world of already existing technical objects are made to interrelate in a concretization that is organic and that is defined by its relational function. Like a vault that is stable only when it is completed, this object fulfilling a relational function can neither endure nor cohere until it has begun to exist and because it exists; it creates its associated milieu from itself and is really individualized in it.

II.—TECHNICAL INVENTION: GROUND AND FORM IN THE LIVING AND IN CREATIVE THOUGHT

So it can be affirmed that the individualization of technical beings is the condition for technical progress. Such individualization is possible because of the recurrence of causality in a milieu that the technical being creates around itself and which conditions it as it in turn is conditioned by the technical being. This milieu at the same time technical and natural can be called an associated milieu. By means of this the technical being becomes conditioned in its functioning. This milieu is not fabricated, or at least it is not wholly fabricated; it is a definite system of natural elements surrounding the technical being and linked to a definite system of elements that constitute the technical being. The associated milieu is a mediator of the relation between fabricated technical elements and natural elements within which the technical being functions. Such is the ensemble constituted by oil and water in motion within the Guimbal turbine and around it. This ensemble is concretized and individualized by the recurring thermal changes that take place within it: the faster the turbine turns the faster the generator expels heat by Joule effect and magnetic losses; but the faster the turbine turns the greater is the increase in turbulence of oil around the rotor and of water around the crankcase, activating the thermal exchanges between rotor and water. This associated milieu is the condition for

the existence of the invented technical object. Strictly speaking, the only technical objects that can be said to be invented are those that need an associated milieu to make them viable; indeed, they cannot be formed part by part during the phases of a gradual evolution because they can exist only in their completeness or not at all. Technical objects which, in their relation with the natural world, essentially involve a recurrent causality must be invented rather than developed gradually, because these objects are the cause of their condition of functioning. These objects are viable only if the problem is solved, that is to say, only if they exist along with their associated milieu.

This is the reason why we notice so much discontinuity in the history of technical objects that have absolute origins. Only thought that is capable of prevision and capable of creative imagination can bring about this reversed conditioning in time: elements that will materially constitute the technical object, and are separated one from the other, without an associated milieu preceding the constitution of the technical object, must be organized in relation to one another as a function of a circular causality that will exist once the object is constituted; what is involved here, then, is a conditioning of the present by the future, a conditioning of the present by what does not yet exist. It is only very rarely that such a function of the future can happen by chance; it necessitates the implementation of a capacity to organize elements with a view to some requirements that have ensemble value, directive value, and that play the role of symbols representing the future ensemble that does not yet exist. The unity of the future associated milieu in which causal relations will be deployed that are to make possible the functioning of the new technical object is *represented, acted* as a role can be acted in the absence of the real character, by the schemes of the creative imagination. The dynamism of thought is the same as that for technical objects; mental schemes inter-react during invention in the same way as different dynamisms of the technical object react to each other in material functioning. The unity of the associated milieu of a technical object has an analog in the unity of the living being; during invention this unity of the living being is the coherence of the mental schemes that derive from the fact that they exist and that they are deployed in the same being; those that are contradictory confront each other and are reduced. Because of being an individual who brings with him his associated milieu, the living being is able to invent; this capacity to be self-conditioning is basic to the capacity to produce objects that are self-conditioning. What has escaped the attention of psychologists in their analysis of the inventive imagination is not so much the schemes or the forms or the operations of this faculty, those elements that spontaneously stand out in relief, as the dynamic ground on which these schemes confront each other, combine with each other, and with which they participate. The psychology of Form, even though it sees clearly the function of totalities, has attributed force to form; a deeper analysis of the imaginative process would no doubt show that the determining factor playing an energizing role is not forms but what supports forms, namely their ground; marginal as it may always be in terms of attention, the ground is what harbors dynamisms; it is what gives existence to the system of forms; forms interact not with forms but with their ground, which is the system of all forms or, better still, the common reservoir of the tendencies of forms, even before they exist separately or are constituted as a specific system. The participative relationship connecting forms to ground is a relationship that spans the present and disseminates an influence of the future on the present, of the virtual on the actual. The ground is the system of potentialities, of potentials, of progressive forces, whereas forms

are the system of the actual. Invention is a taking charge of the system of actuality by the system of potentialities, the creation of a single system from those two systems. Forms are passive insofar as they represent actuality; they become active when they are organized in relation to their ground, thus introducing earlier potentialities to actuality. Undoubtedly it is very difficult to clarify those modalities by which a system of forms can relate to a ground of potentialities. We can only say that it happens according to the same mode of causality and conditioning as that by which each of the structures of a constituted technical object relates to the dynamisms of the associated milieu; these structures are in the associated milieu, are conditioned by it, and through it by the other structures of the technical object; in turn, they condition it, partially, but each for its own sake, whereas the technical milieu, which is conditioned by each structure separately, conditions them all together by supplying them with energetic, thermal, chemical conditions of functioning. There is a recurrence of causality between the associated milieu and the structures, but this recurrence is not symmetrical. The milieu plays an informational role; it is the seat of self-regulation, the vehicle for information or for information-controlled energy (for example, water animated at fairly rapid speed fairly quickly cools a crankcase); while the associated milieu is homeostatic, the structures are animated by a non-recurrent causality; each goes in its own direction. Freud analyzed the influence of ground on forms in psychic life by interpreting it in terms of the influence of other hidden forms on explicit forms; hence the notion of repression. Indeed, experiments have shown that symbolization exists (experiments on a hypnotized subject who hears a violently emotional scene recounted and who, on waking up, uses a symbolic transposition in retelling the scene), but not that the unconscious is populated by forms comparable to explicit forms. The dynamic of tendencies is sufficient to explain symbolization if we accept as meaningful the existence of a psychic ground on which are deployed, and in which participate, explicit forms that the conscious state and the waking state show forth. The milieu associated with the systematic of forms institutes recurrent causal relations between these forms and causes reorganizations of the system of forms collectively. Alienation is a rupture between ground and forms in psychic life: the associated milieu no longer effectively regulates the dynamism of forms. The reason why the imagination has been badly analyzed up to the present day is that forms have been accorded the privilege of activity and have been thought to have the initiative in psychic life and in physical life. In reality, there is a strong kinship between life and thought: in the living organism all living matter cooperates with life; the most obvious and clearly defined structures in the body are not the only ones that have life initiative: blood, lymph, and conjunctive tissues play their role in life; an individual is not only made of a collection of organs linked together in systems; he is also made of something that is neither an organ nor a structure of living matter in the sense of its constituting an associated milieu for the organs; living matter is the ground of the organs; it is what connects them to each other and makes them an organism; it is what maintains the fundamental equilibriums, both thermal and chemical, on which organs exert sudden, though limited, variations; the organs participate in the body. The living matter in question is far from being pure indeterminacy and pure passivity; neither is it blind aspiration: it is a vehicle of informed energy. Likewise, thought comprises precise and separate structures such as representations, images, and some memories and perceptions. But all these elements participate in a ground that gives them a direction, a homeostatic unity, and that conveys

informed energy from one to the other and from all to each. We could say that the ground is the implicit axiomatic; in it are elaborated new systems of form. Without the ground of thought, there would be no thinking being, but, instead, a disconnected series of scattered representations. This ground is the mental milieu associated with forms. It is the middle term between life and conscious thought, just as the milieu associated with the technical object is a middle term between the natural world and fabricated structures of the technical object. We are able to create technical objects because we have within ourselves an inter-play of relations and a matter-form relationship which is remarkably similar to that which we institute in the technical object. The relationship between thought and life is analogous to the relationship between the structured technical object and the natural environment. The individualized technical object is an object that has been invented, that is to say a product of the interplay of recurrent causality between life and thought in man. The object that is associated only with life or thought is a utensil or tool but not a technical object. It has no internal consistency, because it has no associated milieu instituting a recurrent causality.

III.—TECHNICAL INDIVIDUALIZATION

The principle of the individualization of the technical object by recurrent causality in its associated milieu makes it possible to think all the more clearly about certain technical ensembles and to know whether they should be treated as a technical individual or as an organized collection of individuals. We can identify a technical individual when the associated milieu exists as a *sine qua non* condition of its functioning, and we can identify an ensemble when the opposite is the case. Let us consider a laboratory such as a laboratory for the study of the psychology of sensations. Is an audiometer a technical individual? No, if we think of it apart from the power supply sector and the headphones or loudspeakers that are used as electro-acoustic conductors. The audiometer is then defined as having to be placed in certain conditions of temperature, voltage, and noise-level in order to stabilize frequencies and intensities and to make threshold measurements possible. The coefficient of absorption of the room and its resonances at various frequencies should be taken into consideration; the locale is part of the complete apparatus: audiometry requires either that it be activated out in the open country or that measurements be taken in a sound-proof room, with anti-microphonic floor suspension and with heavy layers of glass wool on the walls. What is the audiometer essentially, as sold by its manufacturer or as home-made? It is an ensemble of technical forms with relative individuality; so, it has two high frequency oscillators, one of them fixed, the other variable; of the two frequencies, the one with the lower beat produces the audible sound; an attenuator makes it possible to control the intensity of stimuli. On its own neither of the oscillators is a technical object, because in order to be stable it needs stabilized filament supply and anode supply. In general this stabilization is obtained by means of a recurrent causality electronic system that functionally constitutes the associated milieu for the technical forms of oscillators; however, this associated milieu is not entirely an associated milieu; rather, it is a transfer system, a means of adaptation that enables oscillators not to be conditioned by the external milieu, whether natural or technical; this milieu would not be a genuine associated milieu unless a chance drift in the frequency of one of the oscillators resulted in a variation in the supply-voltage that works against such a drift in

frequency; so there would be an exchange between the supply regulator and the oscillators through reciprocal causality; the ensemble of technical structures is what would be self-stabilized; here on the contrary, only the supply is self-stabilized and it does not react to chance variations in the frequency of one of the oscillators.

There is a great theoretical and practical difference between these two cases: indeed, if the power supply is simply stabilized without a recurrent causality link with the oscillators, it would be easy to limit or extend the simultaneous uses of the power supply; for example, a third oscillator can be plugged in to the same supply without interfering with its operation as long as the normal limits of output are not exceeded; on the other hand, to get an efficient retroactive regulation, it is necessary that no more than a single structure should be attached to a single associated milieu; otherwise, chance variations opposite in direction to the two structures non-synergistically attached to the same associated milieu could offset one other and fail to result in a regulatory reaction; structures attached to the same associated milieu should function synergistically. For that reason, the audiometer comprises at least two distinct parts that cannot be self-stabilized by the same associated milieu: the frequency generator, on the one hand, and the amplifier-attenuator, on the other. One of these ensembles cannot be allowed to act on the other, so the two connecting leads must be carefully separated and, in order to prevent inter-action of any kind, the wall separating the two must be electronically and magnetically reinforced. By contrast, the material limitation of the audiometer is not a functional limitation; the amplifier-attenuator is normally run by the acoustic reproductive system and by the room or by the outer ear of the subject, depending on whether connection with the subject is made by loudspeaker or headphones. At the same time, one can postulate the existence of relative levels of individualization in technical objects. This criterion has an *axiological value*: the coherence of a technical ensemble is full when that ensemble is made up of two sub-assemblies with the same level of relative individualization. So in a laboratory for the physiology of sensations there is no benefit from grouping the two oscillators of the audiometer and the amplifier-attenuator; on the contrary, there is an advantage in grouping the two oscillators, so that both could respond at the same time and to the same degree to a variation in voltage or in temperature, so that the variation in lower beat that results from these two correlative variations in frequencies in each of the oscillators is reduced as much as possible, assuming that the two basic frequencies will rise and fall at the same time. On the other hand, it would be totally contrary to the functional unity of the beat-frequency generator to use two separate power supplies and to connect the power supply of an oscillator to one phase of the sector and the second to the other phase. This would disrupt the self-stabilization effect by offsetting two variations which provide the ensemble of the two oscillators with great stability in low beat frequencies. Still, it is useful to plug the oscillators into a network phase different from that to which the amplifier attenuator is connected, so as to prevent the supply voltage of the oscillators from reacting to variations in the anodic consumption by the amplifier.

The principle of the individualization of technical objects in an ensemble is therefore that of sub-assemblies of recurrent causality in the associated milieu; all the technical objects with a recurrent causality in their associated milieu should be separated from one another and should be connected in a way that preserves the mutual independence of their associated milieus. For this reason, the sub-assembly of the

oscillators and that of the amplifier-attenuator-reproducer should be not only independent in power supply but also independent in their coupling: amplifier input should be of very high impedance in relation to the outlet of the oscillators, so as to insure that amplifier reaction to the oscillators is very weak. If, for example, the attenuator were connected to the outlet of the oscillators, the setting of the attenuator would respond to the frequency of the oscillators. An ensemble of higher degree comprising all these sub-assemblies is defined by its capacity freely to bring about a certain relationship without destroying the autonomy of the individualized sub-assemblies. This, for example, is the role of the general selector and connections panel in a laboratory; the electronic and electromagnetic armor and the use of non-reactive couplings such as what we call *cathode-follower* are designed to maintain the said independence of sub-assemblies, while allowing for different necessary combinations between the operations of the sub-assembly; the utilization of the results of functioning without any interaction in the conditions of functioning, that is the second degree of the functional role of the ensemble that we could call a laboratory.

We might ask, then, on what level is individuality: on the level of sub-assemblies or of the ensemble? The answer must be given, as usual, with reference to the criterion of recurrent causality. Indeed, at the level of the higher ensemble (such as that of the laboratory), there is really no associated milieu; if one does exist, it is only in some respects, and it is not general; so, the presence of oscillators in a room where an experiment in audiometry is taking place is often cumbersome; if the oscillators use transformers with an iron magnetic circuit, the magnetostriction* of the metal plates causes a vibration that emits a disturbing sound. An oscillator with resistors and capacities also emits a slight sound as a result of alternative electric attractions. For delicate experiments it is necessary to place the devices in a separate room and to operate them by remote control or else to isolate the subject in a soundproof room. Likewise, magnetic radiation in power transformers can greatly interfere with amplifiers in electroencephalographic and electrocardiographic experiments. For this reason, the higher ensemble which is the laboratory is made up of non-connected devices in order to avoid chance creation of associated milieus. The ensemble is different from technical individuals in that the creation of a single associated milieu is undesirable; the ensemble comprises a number of devices to prevent any possibility of the creation of a single associated milieu. It avoids the interior concretization of the technical objects it contains, and it only uses the results of its functioning, without allowing any interaction of their conditioning.

Below the level of technical individuals, are there still groupings with some individuality? --- Yes, but their individuality does not have the same structure as that of technical objects with an associated milieu; it is that of multifunctional composition without a positive associated milieu, that is to say, without self-regulation. Take for instance the case of a hot-cathode tube. When this tube is inserted into an assembly with an automatically polarized cathode resistance, it becomes the seat of self-regulatory phenomena; for example, if the heating voltage increases, the cathode emission increases, and this causes an increase in negative polarization; the tube no longer increases in amplification and its output scarcely rises, and this is also true of its anode dissipation; a similar phenomenon insures that Class A* amplifiers automatically equalize output levels despite variations in the input level of the amplifier. But such regulatory

counter-reactions are not seated only in the inside of the tube; they depend on the whole assembly, and, in some cases, with specific assemblies, do not exist at all. In this way, a diode whose anode heats up becomes a conductor in both directions, and this also increases the intensity of the current that goes through it; the cathode, receiving the electrons from the anode, heats up increasingly, and increasingly emits electrons: this destructive process is therefore an example of a circular causality that is part of the assembly as a whole and not of the diode only.

Infra-individual technical objects can be called technical elements; they differ from true individuals in that they do not have an associated milieu; they can be integrated into an individual; a hot-cathode tube is more a technical element than a complete technical individual; it can be compared to an organ in a living body. In this sense it would be possible to define a general organology, which would be a study of technical objects at the level of the element, and which would be part of technology, with mechanology, which would study complete technical individuals.

IV. – EVOLUTIONARY CONCATENATIONS AND TECHNICITY CONSERVATATION. THE LAW OF RELAXATION

The evolution of technical elements can have repercussions on the evolution of technical individuals; composed of elements and an associated milieu, technical individuals depend to some extent on the characteristics of elements that they implement. So, electric magnetic engines can be much smaller today than in the days of Gramme, because their magnets are much smaller. In some cases, elements are like a crystallization of an earlier technical operation that produced them. Thus, grain-oriented magnets, still described as magnetically tempered magnets, are produced by a process that consists in maintaining a strong magnetic field around the molten mass which following cooling will be the magnet; the molten mass begins to be magnetized above the Curie point* and then this intense magnetization is maintained while the mass is cooling; when the mass is cold, it is a more powerful magnet than it would have been had it been magnetized after cooling. All this happens as if the strong magnetic field caused a fixing of the molecules in the molten mass, an orientation that continues after cooling if the magnetic field is preserved during cooling and the transition to solidification. Now, the furnace, the crucible, and the coils creating the magnetic field constitute a system that is a technical ensemble; the furnace heat should not affect the coils and the field of induction creating that heat in the molten mass must not neutralize the continuous field designed to produce magnetization. This technical ensemble is itself made up of a number of technical individuals that are mutually organized according to the result of their functioning and in such a way that they do not interfere with the conditioning of their specific functioning. Hence, in the evolution of technical objects we witness a causal transition from earlier ensembles to later elements; when those elements are introduced into an individual and modify its characteristics, they make possible for technical causality to rise from the level of elements to the level of individuals, and then from the level of individuals to the level of ensembles; thence, in a new cycle, technical causality descends once more by a manufacturing process to the level of elements where it is reincarnated in new individuals and, later, in new ensembles. So, there is a line of causality that is not rectilinear, but serrated, the same reality being first in the form of an

element, next having the characteristics of an individual, and finally having the characteristics of the ensemble.

There is a historical solidarity between technical realities that is transmitted through the production of elements. If a technical reality is to have descendants, it needs more than self-improvement: it must also be reincarnated and participate in that cyclical becoming in a form of relaxation in the levels of reality. The solidarity of technical beings in relation to one another in the present generally obscures that other more essential reality, one that requires a temporal dimension of evolution, but is not identical to biological evolution, because it hardly involves any successive changes in level and takes place along more continuous lines. Transposed into biological terms, technical evolution would consist in the fact that a species would produce an organ which would be given to an individual, thereby becoming the primary term of a specific lineage which in its turn would produce a new organ. In the domain of life, the organ cannot be detachable from the species; in the technical domain, the element, precisely because it is manufactured, is detachable from the ensemble that produced it; that is the difference between the *engendered* and the *product*. So, the technical world has a historical as well as its spatial dimension. Its solidarity at a given moment should not obscure the solidarity of the successive; indeed, by its law of serrated evolution the latter solidarity is what determines the major epochs of technical life.

A rhythm of relaxation of this kind has no correspondent anywhere else; neither the human world nor the geographic world is capable of producing oscillations of relaxation, with their repeated accesses, the sprouting of new structures. This relaxation time is technical time proper; it can become dominant in relation to all other aspects of historical time, so that it can synchronize other rhythms of development and seems to determine all historical evolution when it merely synchronizes it and induces its evolutionary phases. As an example of this evolution according to a rhythm of relaxation we could take the evolution of energy since the eighteenth century. A large part of the energy used in the eighteenth century came from waterfalls, from displacements of atmospheric air, and from animals. These kinds of driving power corresponded to exploitation for artisanal purposes or were used in small factories here and there along the water ways. Those small-scale factories led to the high efficiency thermodynamic machines of the beginning of the nineteenth century, and [they led to] the modern locomotive, a result of adapting Stephenson's valve gear to the Marc Seguin tabular boiler, which was light and smaller than a French boiler, [an adaptation] that made it possible to vary the relationship between admission time and the expansion time and also to gradually to go into reverse (steam reversal) by using the neutral. This craft-type mechanical invention which gives the traction engine the capacity to be applied to a great range of profiles, with great variation in engine torque, with a loss of output only in systems of very high power (where admission time is almost equal to the whole of the stroke cycle), makes thermal energy easily adaptable to rail haulage. The Stephenson valve gear and the tabular boiler, elements derived from the artisanal ensemble of the eighteenth century, enter into the new individuals of the nineteenth century, particularly in the form of the locomotive. High tonnage transportation, now possible across all kinds of terrains and no longer following contour lines and the meanders of navigation channels, leads to the industrial concentration of the nineteenth century, which not only incorporates individuals whose functioning principle is based on thermodynamics, but

which is essentially thermodynamic in its structures; so, the great industrial ensembles of the nineteenth century at its apogee were concentrated around coal sources of thermal energy and close to places where there was greatest use of thermal energy (coal mines and iron works). The route of progression went from the thermodynamic element to the thermodynamic individual and from thermodynamic individuals to the thermodynamic ensemble.

Now, the key aspects of electrotechnics make their appearance as elements produced by thermodynamic ensembles. Before becoming autonomous, the applications of electric energy appear as very flexible means of energy transmission from one place to another by means of a power line. Metals with high magnetic permeability are elements produced by applications of thermodynamics to metallurgy. Copper cables and the high resistance porcelains for insulators emerge from steam-powered wire mills and coal furnaces. The metallic frameworks of pylons and cement for dams come from great thermodynamic concentrations and as elements they enter into new technical individuals, such as turbines and alternators. So a new ascent, a new constitution of beings is enhanced and given concrete expression. In the production of electric energy the Gramme machine makes way for the multiphase alternator; the continuous currents of the first energy transmissions make way for alternating currents of constant frequency that are adapted to heat turbine production and consequently to hydraulic turbine production too. These electro-technical individuals became part of ensembles for the production, distribution, and use of electric energy, ensembles whose structure differs very much from the structure of thermodynamic concentrations. The role once played by railways in the thermodynamic concentration has been replaced by the role high voltage transmission lines play in the ensemble of industrial electricity.

When electrical technics reach their full development, they produce in the capacity of element new schemes that begin a new phase: first particle acceleration is initially achieved by electric fields and then by continuous electric fields and by alternating magnetic fields, and this leads to the construction of technical individuals following the discovery that nuclear energy can be exploited; the next thing to happen, remarkably, and thanks to electrical metallurgy, was the possibility of mining metals such as silicon which enable the transformation of the radiant energy of light to electric current, with an output that already attains a significant rate for limited applications (6%), and which is not much lower than the output of the first steam-engines. The pure silicon photo cell, a product of the great industrial electrotechnical ensembles, is one element that has not yet been incorporated into a technical individual; up to now it is only an object of curiosity situated at the extreme point of the technical possibilities of the electrometallurgical industry, but it is possible that it may be the starting point for a phase of development similar to one we have known, and which has not yet reached its completion, with the development of the production and utilization of industrial electricity.

Now, each phase of relaxation is capable of synchronizing minor or almost equally important aspects. So, the development of thermodynamics went hand in hand with that of the transportation not only of coal but of railway passengers; by contrast, the development of electrotechnics went hand in hand with the development of automobile transportation; even though in principle the automobile is thermodynamic, it uses electric energy as an essential auxiliary system, especially for ignition. Industrial decentralization that has been made possible by long distance transmission of electric energy needs the

automobile as a correlative means of transporting people to places that are far apart and to different altitudes, where there are roads but no rail. The automobile and the high voltage wire are parallel technical structures, synchronized but not identical: electric energy, at the moment, does not yet lend itself to automobile driving.

Similarly, there is no relationship between nuclear energy and the energy derived from the photoelectric effect; nevertheless, these two forms are parallel and their developments are likely to be mutually synchronized[2]; so, in all probability, nuclear energy will long remain inapplicable in any direct way to restricted applications, such as those consuming a few dozen [*dizaines*] watts; as opposed to this, photoelectric energy is very decentralizable; it is essentially decentralized in its production, whereas nuclear energy is essentially centralized. The relationship that once existed between electrical energy and energy derived from gasoline combustion still exists between energy of nuclear origin and energy of photoelectric origin, with perchance a more pronounced difference.

V.—TECHNICITY AND THE EVOLUTION OF TECHNICS: TECHNICITY AS AN INSTRUMENT OF TECHNICAL EVOLUTION

The different aspects of the individualization of the technical being constitute the centre of an evolution that proceeds by successive stages, but that is not dialectic in the strict sense of the term, because the role of negativity in this case is not to be an engine of progress. In the technical world negativity is a flaw in individuation, an incomplete junction of the technical world and the natural world; this negativity is not an engine of progress; or, rather, it is an engine of change in that it prompts man to look for new solutions that are more satisfactory than those he has. But this desire for change does not directly affect the technical being; it only affects man as inventor and as user; furthermore, this change should not be mistaken for progress; a too rapid change works against technical progress, because it is an obstacle to the transmission, in the form of technical elements, of what one era has acquired to the era that follows it.

The existence of technical progress requires that each era must pass on to the next era the fruit of its technical effort; what can be transmitted from one era to another is not technical ensembles, nor individuals either, but the elements that these individuals, grouped as ensembles, were able to produce; indeed, technical ensembles, thanks to their capacity for in-house intercommutation, have the possibility of going beyond themselves by producing elements different from their own. Technical beings are in many ways different from living beings, but they are essentially different in this respect: a living being engenders other beings that are like itself, or that can become like it after a number of repeated reorganizations that occur spontaneously if conditions are suitable; on the other hand, a technical being has no such capacity; it cannot spontaneously produce other technical beings like itself, despite the efforts of cyberneticians who have tried to

[2] And of being combined: a solar cell can be irradiated by a radioactive source.

make technical beings copy the living by constructing beings like themselves: that is not possible at present except in a speculative and baseless way; but the technical being has a larger freedom than the living, which depends on a perfection that is infinitely less large; in these conditions, the technical being can produce elements that retain the degree of perfection attained by a technical ensemble and those elements can be brought together to make possible the constitution of new technical beings, in the form of individuals; so here there is neither engendering nor procession nor direct production, but indirect production by the constitution of elements incorporating a certain degree of technical perfection.

This affirmation calls for a detailed explanation of what we mean by technical perfection. From an empirical and external point of view, we could say that technical perfection is a practical quality or at the very least the material and structural support of practical qualities; hence, a good tool is not merely a well made and well shaped tool. From a practical point of view, an adze can be in bad condition and poorly sharpened and still it may not be a bad tool; an adze is a good tool if, on the one hand, its curvature is suitable for a straight and well directed stroke on the wood and if, on the other hand, it can take and keep a keen edge even when it is used on hard woods. Now, this last quality is the product a technical ensemble that was used to make the tool. As a manufactured element an adze can be made of a metal whose make-up varies at different points: this tool is not simply a homogeneous metal block shaped to have a certain form; it has been forged, which means that the molecular chains in the metal have a certain orientation which varies with locations, like a wood with fibers so disposed as to give the greatest solidity and the greatest elasticity, especially in the middle parts between the cutting edge and the heavy flat part that goes from the socket to the cutting edge; this area close to the cutting edge becomes elastically deformed during work because it acts as wedge and lever on the wood chip in the lifting process. Finally, the cutting edge is more strongly steel-plated than any other part; and it has to be strongly steel-plated, though in a carefully delimited way, for otherwise a too great weight of steel-plated metal would make the tool brittle and the edge would shatter. It is as if the tool as a whole were made of a plurality of differently functioning zones soldered together. The tool is not made of matter and form only; it is made of technical elements developed in accordance with a certain scheme of functioning and assembled as a stable structure by the manufacturing process. The tool retains in itself the result of the functioning of a technical ensemble. The production of a good adze requires the technical ensemble of the foundry, the forge, and quench-hardening.

The technicity of the object is therefore more than a quality of usage; in the object it is what is added to a primary purpose established by the relationship between form and matter; it is as it were the intermediary between form and matter, here for example, the progressive heterogeneity of quench-hardening on the different points [parts of the adze]. The technicity of an object is the degree of concretization of the object. It was this concretization that, in the days of the wood foundry, created the worth and fame of Toledo blades and, some time ago, the quality of St. Etienne steels. These steels are an expression of the result of the functioning of a technical ensemble which comprised the characteristics of the coal used as much as the temperature and chemical composition of the non-chalky waters at Furens, or the essence of the green wood used to stir and refine the molten metal prior to casting. In certain cases, technicity becomes

preponderant with regard to the abstract characteristics of the matter-form relationship. Thus, a coil spring is a very simple thing in form and matter; nevertheless, the manufacturing of springs requires a high degree of perfection in the technical ensemble that produces them. Often, the quality of individuals such as an engine or amplifier depends much more on the technicity of simple elements (valve springs, for instance, or a modulation transformer) than on the ingenuity of the assembly. Now, technical ensembles capable of producing such simple elements as a spring or a transformer are sometimes extremely large and complex, almost co-extensive with all the ramifications of many worldwide industries. It would be no exaggeration to say that the quality of a simple needle expresses the degree of perfection of the industry of a nation. This is the reason for those fairly legitimate judgments, both practical and technical, which call a needle "an English needle." Judgments such as these are meaningful, because technical ensembles are reflected in the simplest elements they produce. Admittedly, this way of thinking exists for less legitimate reasons, particularly because it is easier to describe a technical object in terms of its origin than to judge its intrinsic value; that is a phenomenon of opinion; but this phenomenon, though it may give rise to many an intentional exaggeration or exploitation, is not without foundation.

Technicity can be looked upon as a positive characteristic of the element, as analogous to the self-regulation effected in the technical individual by its associated milieu. At the level of the element, technicity is concretization; it is what ensures that the element produced by an ensemble is really an element and is not itself an ensemble or an individual; this characteristic makes it detachable from the element and sets it free so that the new individuals can be constituted. Admittedly, there is no peremptory reason for assigning technicity only to the element; the associated milieu is a custodian of technicity at the level of the individual, as is the scope of intercommutativity at the level of the ensemble; still, it proper to reserve the term technicity for that quality of the element that expresses what it has acquired in a technical ensemble and what it retains to be transported to a new era. Concretized technical reality is what is transported by the element, whereas the individual and the ensemble contain this technical reality without being able to transport and transmit it; they are able to produce or retain, but they cannot transmit; elements have a transductive property that makes them the true bearers of technicity, just like grains that carry the properties of the species and will make new individuals once again. Therefore it is in elements that technicity exists in the purest way, in its free state so to speak, whereas in individuals and in ensembles it exists only in the state of combination.

Now, the technicity carried by elements has no negativity, and no negative conditioning comes into play at the time of the production of elements by ensembles or of individuals by invention, which brings elements together to form individuals. Invention, a creation of the individual, assumes that the inventor has an intuitive knowledge of the technicity of elements; invention is achieved at that intermediary level between the concrete and the abstract which is the level of schemes; it assumes the prior existence and the coherence of the representations that cover the technicity of the object with symbols that belong to imaginative systematics and dynamics. Imagination is more than a faculty for inventing or creating representations beyond the bounds of sensation: it is a an ability to perceive in objects qualities that are not practical, qualities that are neither

directly sensory nor entirely geometrical, qualities that relate neither to pure matter nor to pure form, but that belong to the intermediary level of schemes.

We can consider the technical imagination to be defined by a distinctive responsiveness to the technicity of elements; this responsiveness to technicity is instrumental in the discovery of possible assemblies; the inventor does not begin *ex nihilo,* starting with matter and giving it form, but with elements that are already technical, to which is introduced an individual being that is capable of incorporating them. The compatibility of the elements in the technical individual requires the associated milieu: so the technical individual has to be imagined, that is to say assumed to be constructed as an ensemble of ordered technical schemes; the individual is a stable system of the technicities of elements organized into an ensemble. The technicities are organized, and the elements also are organized as supports for these technicities, not the elements themselves taken in their materiality. An engine is an assembly of springs, shafts, and volumetric systems, defined by their characteristics and their technicity, not by their materiality; also a relative indeterminacy can subsist in the localization of any one element in relation to all the others. The place of some elements is chosen more for extrinsic considerations than for intrinsic considerations about the single technical object in relation to various processes of its functioning. The intrinsic determinations, depending on the technicity of each of the elements, are those that constitute the associated milieu. Now, the associated milieu is the concretization of the technicities borne by all the elements in their mutual responses. Technicities can be conceived of as stable conduits that express the characters of elements rather than as simple qualities: they are powers in the fullest sense of the word, that is, capacities for producing or for undergoing an effect in a specific manner.

The higher the technicity of an element is raised, the more the margin of indeterminacy of this power diminishes. This is what we wanted to say in stating that the elementary technical object materializes when its technicity increases. This power could also be named a *capacity,* as long as it is understood that it is characterized with reference to a specific use. Generally speaking, the more the technicity of an element increases the more the scope of its conditions of use increases, because of the high stability of the element. So, the technicity of a spring is raised when it can withstand higher temperatures without loss of elasticity and can preserve without critical modification its coefficient of elasticity within more extensive thermal and mechanical limits: technically, it remains a spring within larger limits, and it is suitable for less restricted conditions of incorporation into one or other technical individual. An electrolytic condenser* has a lower degree of technicity than a dry paper or mica dielectric condenser. In fact, an electrolytic condenser has a capacity that varies in function according to the voltage to which it is submitted; in use its thermal limits are more limited. It varies when subjected to constant voltage because like electrodes the electrolyte becomes chemically modified in the course of its functioning. Dry dielectric capacitors, on the other hand, are more stable. Still, here again, the quality of technicity increases with the independence of characteristics in relation to the conditions of use; a mica condenser is better than a paper condenser, and the vacuum condenser is best of all, because it is not subject to the condition of voltage limit that arises when there is a risk of perforating the insulator; at an intermediary degree, the silvered-ceramic condenser, which varies very little with temperature, and the air condenser too, provide a high degree of

technicity. In this respect, it should be pointed out that there is no necessary correlation between the commercial price of a technical object and its basic technical quality. Very often, considerations of price have no absolute influence, though they may exert some influence because of other concerns such as place; hence, an electrolytic condenser is preferable to a dry dielectric condenser when high capacity would require too large a space to accommodate the condenser; likewise, an air condenser is very bulky in comparison with a vacuum condenser of the same capacity; yet, it is much cheaper and also in a dry atmosphere it is every bit as reliable in operation. So, in a great number of cases, economic factors are influential not directly but through the effect of the degree of concretization of the technical object on its use in the individual ensemble. This economic effect has an impact on the generic formula of the individual being, not on the element as element. The connection between the technical domain and the economic domain takes place at the level of the individual or of the ensemble, but very seldom at the level of the element; for this reason, we can say that technical value is to a great extent independent of economic value and that it can be appraised by independent criteria.

This transmission of technicity by elements establishes the possibility of technical progress over and above apparent discontinuity in forms, domains, and kinds of energy used and, occasionally, even of operational schemes. Each stage of development is a legatee of earlier eras, and progress is all the more certain the more completely and perfectly it tends towards the status of universal legatee.

The technical object is not, strictly speaking, a historical object: in the course of time, it has been treated only as a vehicle of technicity, because of the transductive role it plays between one age and the next. Neither technical ensembles nor technical individuals last; only elements have the power to transmit technicity from one era to another in a form that is complete, accomplished, and materialized in a product. This is the reason why it is appropriate to analyze the technical object as consisting of technical individuals; but it is necessary to specify that at certain times in its evolution the technical object has meaning in itself and is a depository of technicity. In connection with this, it is possible to base the analysis of the technics of a human group on the analysis of the elements produced by their individuals and their ensembles: often, these elements alone are able to survive the collapse of a civilization, and they remain as legitimate witnesses to one state of technical development. In this sense, the method of the ethnologists is perfectly valid; but its application could be extended by also making an analysis of the elements produced by industrial technics.

Indeed, there is no fundamental difference between peoples who have no industry and those who have a well developed industry. Even among peoples with no industrial development there are technical individuals and technical ensembles; however, instead of being stabilized by the institutions that establish them and that perpetuate them by installing them, these individuals and these ensembles are temporary or even occasional; what are retained from one technical operation to another are the elements, that is to say tools or manufactured objects. The construction of a boat is an operation that requires a real technical ensemble: fairly flat ground, though near a water-course, sheltered too, though with good light, and, as well as all this, supports and props to keep the boat standing during construction. As a technical ensemble, the shipyard may be temporary; nonetheless it is a shipyard that constitutes an ensemble. Furthermore, in our day, similar temporary technical ensembles are to be found, some of them highly

developed and quite complex, such as building sites; others are temporary though more durable, for example mines or oil fields.

A technical ensemble does not necessarily have the stable form of the factory or the workshop. Still, it seems that non-industrial civilizations differ from ours especially in having no technical individuals. This is true, as long as it is understood that the material existence of the technical individuals in question is not stable and permanent; however, the function of technical individualization is taken over by human individuals; apprenticeship, by which a man develops habits, movements, and ways of doing things that enable him to use a great variety of tools required by his job as a whole, urges that man to become technically individualized; he becomes the technical milieu of various tools; when he has mastered all the tools and knows when to change tools in order to continue with his task, or when to use two tools at once, he uses his body to insure the internal distribution and self-regulation of the task.[3] In certain cases, the integration of technical individuals into the ensemble is effected through the agency of an association of human individuals working together in twos or threes or in bigger groups; when these groupings do not bring about functional differentiation, their only direct end is to increase the available energy or the speed of work; but when they have recourse to differentiation, they provide a good illustration of the genesis of an ensemble that uses men more as technical individuals than as human individuals: drilling with bow drill as described by the authors of classical antiquity was like that: and even in our own days the felling of certain trees is like that; and so also, until not very long ago, was the very common method of using a cross-cut saw to make planks and rafters; two men worked together, in alternating rhythm. This explains why in certain cases human individuality can be functionally employed as a support for technical individuality; the existence of technical individualities as separate capacities is fairly recent and in some ways it seems to be the imitation of man by the machine, the machine being the most general form of the technical individual. Now, in reality, there is very little similarity between machines and man, and even when they function so as to produce comparable results, machines rarely use procedures like those used in the work of the individual man. In fact, the analogy is most often very superficial. But, if man often feels frustration over the machine, the reason is that the machine replaces him as an individual in the working world: the machine takes the place of man the tool bearer. In the technical ensembles of industrial civilizations, jobs in which many men have to work in tight synchronization are becoming rarer than in the past, a past that was characteristically at the artisanal level. On the other hand, at the artisanal level it is quite common for certain kinds of work to require the grouping of human individuals with complementary functions: to shoe a horse, one man is needed to hold the hoof and another to position the shoe and nail it on. To build, the mason had his assistant, the hod-carrier. In threshing with the flail there is need for a good perception of rhythmic structures so that the alternating movements of the team members can be synchronized. Now, we cannot say that machines replaced assistants

[3] The nobility of artisanal work derives in part from this: man is a depository of technicity, and work is the sole expression of that technicity. The need to work reflects that need for expression; to refuse to work when one has technical knowledge that can only be expressed through work, because it cannot be formulated in intellectual terms, would be to hide one's light under a bushel. As opposed to this, the need for expression is no longer tied to work when technicity has become immanent in knowledge that can be formulated abstractly, outside of any kind of concrete actualization.

only; what changed was the very support of technical individualization: this support had been a human individual; now it is the machine; the machine is the bearer of tools, and it could be defined as that which bears tools and makes use of them. Man manages or regulates the machine, the bearer of tools; he arranges the groupings of machines, but he does not carry tools; the machine really does the main work, the work of the blacksmith, not of his assistant; man, free of the function of technical individual which is the essence of the artisanal function, can become either the organizer of the ensemble of technical individuals or an assistant to technical individuals: he greases, tidies up, picks up debris and burrs, that is to say, in many respects he does a helper's job; he supplies the machine with elements, changing the belt, sharpening the drill or the lathe. So, in this sense, he has one role lower than technical individuality and another role above it: as servant and regulator, he supervises the machine, a technical individual, by attending to the relationship of the machine with its elements and with the ensemble; he is the organizer of relationships between technical levels, instead of his being, himself, one of those technical levels, as a craftsman. For this reason, a technician is less a member of his specialization than a craftsman.

Nevertheless, this in no way means that man cannot be a technical individual or that he cannot work in liaison with the machine; this man-machine liaison is realized when man uses the machine to act upon the natural world; the machine is then a vehicle for action and information in a three-term relationship: man, machine, world, with the machine between man and the world. In this case, man retains traits of technicity defined in particular by the necessity for an apprenticeship. So the machine functions as a relay, as an amplifier of movements, but all the while it is the man who remains the centre of this complex technical individual which is the reality constituted by the man and the machine. One could say that in this case man is the bearer of the machine, while the machine remains a bearer of tools; so the relationship is to some extent comparable to that of the machine tool, if by machine-tool we mean one that has no self-regulation. In this relationship, man is always the centre of the associated milieu; the machine-tool is an item that has no autonomous internal regulation, and that needs a man to make it work. Here man steps in as a living being; he makes use of his own sense of self-regulation to bring about self-regulation in the machine, even without consciously formulating the necessity of this: a man allows an over-heating car engine to "rest" until it cools down, and he gradually gets it going from the cool state without initially revving it up too much. These actions of his, which are technically appropriate, have their parallel in the regulations of life, and these are experienced by the driver rather than thought about. Actions of this kind are all the more applicable to the technical object the closer it gets to the status of the concrete being, including homeostatic regulations in its functioning. Indeed, a technical object that has become concrete has a system that reduces to a minimum the processes of self-destruction, because homeostatic regulations are exerted to the best extent possible. This is the case with the diesel engine, which requires a definite temperature to function and a rotation system within a narrow maximum and minimum range, while the gasoline engine has greater flexibility, because it is less concrete. Similarly, an electronic tube cannot function with any random cathode temperature or with an indeterminate anode voltage; for power tubes in particular, too low a cathode temperature causes the electric field to capture electron-emitting oxide particles; hence the need for a gradual starting procedure, with first the warming of

cathodes that have no anode voltage and then the charging of the anodes. If the bias circuits are automatic (fed by cathode current), they should be turned on by a gradual increase in anode power supply; without such a precaution, there would be a brief moment when a cathode output would already happen before polarization has reached its normal level (the polarization, being the result of this output and proportional to it, tends to limit it): the cathode output, not yet limited by the negative reaction in question, would exceed the permissible maximum.

To put it very generally, the precautions man takes for the conservation of the technical object have as their end to maintain its functioning in, or to lead its functioning to, conditions that render it non-self-destructive, that is conditions in which it subjects itself to a stabilizing negative reaction; beyond these limits the reactions become positive, and as a consequence destructive; as an example, an over-heated engine that becomes too hot begins to jam and, becoming hotter still because of the heat released by the jamming, it is irreversibly damaged; likewise, an electronic tube whose anode becomes red hot loses its asymmetrical conductivity, specifically in its corrective function: it then enters a phase of positive reaction. The fact of letting it cool down early enough allows for the recovery of its normal functioning.

So, man can act as a substitute for the technical individual, and can connect elements to ensembles in an age when the construction of technical individuals is not possible.

In reflecting on the consequences of technical development in relation to the evolution of human societies, it is important, first and foremost, to take account of the process of the individualization of technical objects; human individuality becomes more and more released from his technical role by the construction of technical individuals; the functions that remain for man are higher or lower than his role as bearer of tools, tending towards a relationship with elements and towards a relationship with ensembles. Now, since technical work in the past had precisely exploited the individuality of man, who had to become technicized, since the machine could not be, the custom developed of allotting one sole function to each human individual in the work place; this kind of functional monism was perfectly useful and necessary when man became a technical individual. But that creates a problem today, because man still tries to be a technical individual but has no definite position around the machine: he becomes either a servant of the machine or an organizer of the technical ensemble; now, to make the human function meaningful it is necessary that each man who has a technical task, high or low, around a machine should arrive at some sort of understanding of it, should pay attention to its elements as well as to its integration into the functional ensemble. The reason for this is that it is a mistake to create a hierarchical distinction between the care to be given to elements and the care to be given to ensembles. Technicity is not the kind of reality that lends itself to hierarchical distinctions; it exists wholly in elements, and it is transductively disseminated in the technical individual and in ensembles: ensembles, by way of individuals, are made of elements, and elements emerge from them. The apparent preeminence of ensembles arises from the fact that today ensembles are accorded prerogatives of people in leadership roles. In fact, ensembles re not individuals; likewise, devaluation of elements is the result of the fact that in the past working with elements was a job for an assistant and that the same elements were not well developed. Hence, the malaise in the relationship between man and machine derives from the fact that until our own time one

of the technical roles, that of the individual, was taken by men; now that he is no longer a technical being, man must learn a new function, and must find a position in the technical ensemble that is not the position of the technical individual; the first thing he must do is to take on two non-individual functions, the function of the elements and the function of the director of the ensemble; but in both of these functions man is in conflict with his memory of himself: man has played the role of technical individual to such an extent that the machine which has become a technical individual still seems to be a man and seems to have taken man's place, whereas in actual fact man had provisionally taken the place of the machine before real technical individuals could be made. In all judgments made about the machine, there is an implicit humanizing of the machine, which has this role-change as its ultimate source; man had so well learned to be a technical being that he goes to the extent of believing that once the technical being has become concrete it wrongly begins to play man's role. Ideas about slavery and freedom are much too closely linked with the old status of man as technical object to be able to deal with the real problem of the relation between man and machine. The technical object must be known in itself if the relation between man and machine is to be stable and valid: hence the need for a technical culture.

Gilbert Simondon. *On the Mode of Existence of Technical Objects*

SECOND PART

Man and the Technical Object

Chapter I

The Two Basic Modes of the Human Relationship to Technical Data

1: THE SOCIAL SIGNIFICANCE OF TECHNICS--MAJOR AND MINOR

We would like to show that the technical object can be linked with man in two opposite ways: in accordance with a majority status or in accordance with a minority status. The minority status is that according to which the technical object is primarily a common object, necessary for daily life, and part of the circle within which the individual grows and develops. In this case, the encounter between the technical object and the human takes place principally during childhood. Technical learning is implicit, not thought out, customary. The majority status, on the other hand, corresponds to the awareness and the reflective transaction of the free adult, who has at his disposal the means of rational knowledge developed by the sciences: in this way the knowledge of the apprentice differs from that of the engineer. Once the apprentice becomes an adult craftsman and once the engineer is thrust into the network of human relations, the person retains and radiates about him a vision of the technical object that corresponds, in the case of the former, to the minority status of the object and, in the case of the latter, to its majority status; these two are very different sources of representations and judgements relating to the technical object. Now, the craftsman and the engineer do not live for themselves alone; witnesses and agents of the relationship between human society as a whole and the world of technical objects as a whole, they have exemplary value: through them the technical object is incorporated into culture. Until the present day, these two modes of incorporation have not been able to produce consistent results, so that there are, as it were, two languages and two kinds of thought emerging from the technical, and there is no coherence between one and the other. This lack of coherence is partly responsible for contradictions that modern culture retains today when it judges and imagines the technical object in relation to man.

This conflict between the majority aspect [of the technical object] and its minority aspect is, moreover, just a particular instance of the perennial inadequacy that has existed between man, individual or social, and technical reality. In antiquity, the majority of technical operations were cast out of the domain of thought: these were operations relating to servile occupations. Just as the slave was rejected from the city, so were servile occupations and the

technical objects relating to them banished from the world of discourse, from reflective thought, from culture. Only the Sophists and to some extent Socrates made an effort to introduce the technical operations of slaves and freedmen into the domain of higher thought. Majority status was accorded to only a few operations, such as agriculture, hunting, warfare, and the art of navigation. Techniques that used tools were excluded from the domain of culture (Cicero draws nearly all of his metaphors from the higher arts, and particularly from agriculture and navigation; he rarely refers to the mechanical arts.)

Going further back into the past, one would find that one particular civilization also made a distinction between the higher techniques and the lower. The history of the Hebrew people grants genuine privilege to the techniques of pastoral life and considers the earth as cursed. The Eternal accepts the offerings of Abel but not those of Cain: the shepherd is superior to the farmer. The Bible has a variety of schemes of thought and paradigms drawn from how to make flocks thrive. The Gospels, on the other hand, introduce ways of thinking drawn from agricultural experience. Perhaps, one could discover at the beginnings of mythologies and religions a decided technological prejudice, establishing one technique as prestigious and refusing to give freedom of the city to the others, even when they are of practical use; this initial distinction between a majority technic and a minority technic, between a valued technic and a devalued technic accuses a culture which incorporates technical schemes discovered in this way of being rather biased, non-universal. Our research does not intend to discover in every particular case the reasons and modalities of choice for this distinction between basic technics, but only to show that human thought ought to establish an impartial, non-prejudicial connection between technics and man. This task is still to be done, because there are phenomena of technical dominance which, by insuring that in each age culture privileges one part of the technical world and rejects another, maintain an incomplete relationship between human reality and technical reality.

The suppression of slavery in Western Europe allowed the techniques of slaves in the ancient world to come to light and to be expressed in clear thought: the Renaissance enshrined the techniques of the craftsman by casting on them the light of rationality. Rational mechanics introduced machines into the domain of mathematical thought: Descartes calculated changes of motion in the simple machines used by slaves in antiquity. This attempt at rationalization, which means integration into culture, was to continue until the end of the eighteenth century. But, despite this, the unity of technologies did not prevail; a real reversal occurred, which returned the higher techniques of ancient times (those of agriculture and livestock) to the domain of the irrational, the non-cultural; the relationship with the natural world was lost and the technical object became an artificial object that separates man from the world. Today it is hard to imagine how to reconcile technics-inspired thinking about living beings with the artificialist thinking that constructs automata. The only way mechanical techniques could attain a genuinely majority status was by becoming techniques as conceived by the engineer rather than remaining the techniques of the craftsman; on the artisanal level, the concrete relationship between the world and the technical

object continues; but the object conceived by the engineer is an abstract technical object, with no attachment to the natural world. To incorporate technical objects, culture must discover a middle way between the majority status and the minority status of technical objects. The disjunction between culture and the technical is conditioned by the disjunction that exists within the world of technics itself. To discover an appropriate connection between man and the technical object, it would be necessary to discover unity in the technical world, by way of a representation that would blend together the craftsman's and the engineer's. The craftsman's representation is embedded in the concrete, committed to material manipulation and sentient existence; it is dominated by its object; the engineer's dominates; it makes of the object a bundle of monitored relationships, a product, a set of characteristics.

So, the first condition for the incorporation of technical objects into culture would be that man is neither inferior to nor superior to technical objects, that he should approach them and learn to understand them by having a relationship of equality with them, of reciprocal exchanges: a social relationship in a way.

The compatibility or incompatibility of different technological modes should undergo a conditional analysis. Perhaps it will be possible to discover the conditions of compatibility between a technology such as that of the Romans and another such as the technology that civilized societies are developing in our own day; perhaps it will even be also possible to discover a real though scarcely perceptible incompatibility between the technological conditions of the nineteenth century and those of the middle of the twentieth century. Some myths generated by the improper conflation of two incompatible technological paradigmatisms could then be restored to their initial conditions and analysed.

II. --- THE TECHNICAL AS THE CHILD LEARNS IT AND THE TECHNICAL AS THE ADULT THINKS ABOUT IT

One cannot study the status of the technical object in a civilisation without taking into account the difference between the relationship of this object to the adult and to the child; even if life in modern societies has inculcated in us the habit of believing that there is a continuity between the life of the child and that of the adult, the history of technical education quickly shows us that there was always a distinction between them, that the characteristics of the acquisition of technical knowledge are not the same, and depend on whether it is the child or the adult who acquires the technical knowledge; we have no intention whatever to lay down a prescriptive rule, but only to affirm that the ways of teaching technics have greatly varied over the years and that they have varied not only because of the condition of technics or because of the structure of societies but also because of the age at which subjects were subjected to apprenticeship; here we can discover a circular causal relation between the state of technics and the age at which the knowledge that constitutes the technician's stock-in-trade was acquired; if a poorly rationalized technic requires an extremely early beginning to apprenticeship, the subject, even when he has become an adult, will

continue to have a basic irrationality in his technical knowledge; he will do so because of customary assumptions that are deeply imbued because learned at an early age; incidentally, the technician will express his knowledge not in clearly represented schemes but by a *sleight of hand* which is his almost instinctively and which belongs to that second nature we call habit. His knowledge will be at the level of sensorial and qualitative representations, very close to the concrete nature of matter; such a man will be gifted with a power of intuition and of connivance with the world that will give him a very noteworthy skill which shows in work only and not in consciousness or in speech; the craftsman will be like a magician, his know-how more hands-on than intellectual, more capacity than knowledge; by its very nature, it will be a secret for others because it will be a secret for himself, for his own consciousness.

Once again in our time, the presence of a technical sub-consciousness that reflective activity cannot formulate in clear terms can be found among peasants or shepherds, who can directly understand the importance of seeding, the exposure of land, where best to plant a tree or to place a pen so that it is sheltered and well located. These men are experts in the etymological sense of the word: they share the living nature of the thing they know, and their learning is a participatory learning, profound and direct, that requires an original symbiosis, involving a kind of fraternity with a valued and qualified aspect of the world.

Here man behaves like an animal that smells water or salt from afar and knows immediately and without forethought where to make its nest. Involvement of this sort is by nature instinctive and it happens only when the life of successive generations has made possible an adaptation of the rhythm of life, of the conditions of perception, and of mental structures essential to a kind of activity aimed at a nature that is stable. Hoffman, in a very interesting story entitled *The Mine*, writes of a similar power of intuition in the real miner: the miner senses danger and he knows how to find ore in the most hidden seams; he lives in a kind of connaturality with underground nature, and this connaturality is so profound as to exclude every other feeling or attachment; the real miner is an underground man. Whoever goes down the mine without liking it, like that wandering sailor who bravely takes a job in the mine because he is in love with a girl, will never find that essential connaturality; he will be a victim of the mine, even on the very morning of his wedding. There is no moral nuance here; the young sailor is full of merit and virtue. But he is a sailor, not a miner; he lacks the mine intuition. The ghost of the ancient miner warns him of the danger he is facing, because the mine never accepted the intruder, who comes from the outside, from another trade and from another life, and who is not endowed with the power of involvement. In the peasant, the shepherd, the miner, the sailor, human nature becomes coupled in this way with a second nature which is like an ancestral pact with an element or a land. It is hard to say whether this sense of involvement is acquired in the early years or whether it is part of a hereditary patrimony; but it is certain that such a technical training, consisting of intuitions and purely concrete operational schemes that are very difficult to formulate and difficult to transmit by any oral or figurative symbolism, pertains to childhood. For that same reason, it progresses only with the greatest of difficulty, and can

scarcely ever be improved in adult life: indeed, it is not naturally conceptual or scientific, and it cannot be modified by an oral or written intellectual symbolism.

This technical training is rigid. It would be quite improper to deem this technical training necessarily inferior to a training that use intellectual symbols; this instinctive kind of training has a quantity of information that can be a great as that found in an education containing knowledge clearly explained in symbols, with graphics, designs, or formulae; it is too easy to contrast routine with science, and, at a single stroke, with progress; primitiveness should not be confused with stupidity, just as conceptualisation should not be confused with science. But it is important to note that this technical knowledge is really rigid, because man cannot become a child once again so as to acquire new basic intuitions. Further, this technical form has a second feature: it is initiatory and exclusive; in fact, by being raised in a community that has already been imbued with the habits of a given type of work the child attains basic intuitions; anyone coming from outside the community is very likely deprived of this initial participation which requires experience of the conditions of life, because the conditions of life are educational in this primary sense. Without doubt, it would be improper to attribute the closure of old technics to the closure of community life in societies: indeed, such societies knew how to open up, as we can see from the temporary or seasonal emigration to Paris of peasants from the Auvergne, until close to the end of the nineteenth century; in this case, what corresponds to a closed way of life is the technic itself, because its technical training is valid only for the society that developed it, and is valid for that society only. It seems that historians are inclined to think in a very abstract manner about the initiation rites of ancient crafts, when they deal with them from a purely sociological point of view; it might be said that the ritual ordeals are part of a system for developing the technical knowledge of the child; the ordeal is not only a social rite but also an act by which the young subject becomes an adult by taming the world, by measuring himself against it in a critical situation, and by triumphing over it. There is a certain magical charge in the ordeal, which is an act by which the child becomes a man, by for the first time using all his strengths pushed to the very limit. In this dangerous hand-to-hand encounter with the world and with matter, he risks the effectiveness of his manly action if he weakens or if he is shown to be inferior. If hostile nature does not allow itself to be defeated, the man cannot become a complete adult, because a ditch has been dug between nature and himself; the ordeal is an enchantment of the technical being for life; it is an operation that establishes the obedience of matter to a man who has become its master because he succeeded in taming it, like an animal that becomes docile from the day it first allowed itself to be led. If this first step is missed, the animal rebels and stays untrained; he will never again accept this master, who, in his turn, will always lack confidence, because immediate contact is severed. In the ritual ordeal a law of all or nothing surfaces; the man and the world are transformed in it; in it an asymmetric union begins; we should not say that the ordeal provides a pure demonstration of courage or of skill; the ordeal establishes these qualities, because courage consists in an immediate and sure connection with the world, which distances all uncertainty and hesitation; courage is not fear overcome, but

fear that is always deferred by the presence of an intuition affirming that the world favours the man of action; the skilful man is the man whom the world accepts, whom matter likes and obeys with the trusting docility of the animal that has recognized its master. Skilfulness is one of the forms of power, and power requires an enchantment that makes possible an exchange of forces or, rather, a more primitive and more natural mode of involvement than that of enchantment, a mode already well developed and partly abstract. In this sense, skilfulness is not the exercise of a violent despotism but the use of force that is in keeping with the being it is leading. In the genuine power of the skilful man there is a relationship of recurrent causality. The real technician likes the material he is working on; he is on its side; he is an initiate but he respects what he has been initiated to; he forms a pair with this material, once he has mastered it, and he is reluctant to hand it over to the layman, because he has the sense of the sacred. Even in our days the craftsman and the peasant still feel a distaste for consigning to commerce works or products that express their most refined and perfect technical activity: this prohibition of commerciality, of disclosure, occurs for example when the printers, editors, and authors give away free samples of a book. It occurs also in the case of the Pyrenean peasant who in his own home offers food to a guest, who can neither buy it nor take it away.

The secret and non-progressive nature of such a technic is not merely a product of social conditions; it produces the structure of groups as much as group structure conditions it. And perhaps every technic should to some extent include a coefficient of the intuition and instinct that are necessary for the establishing of suitable communication between man and the technical object. But beside this primary aspect of technical training, there is a second aspect which is the inverse of the former, and which is aimed essentially at the adult man. Like the former, it has a dynamic effect on the individual man and on the group, by leading them to have an adult mentality.

This second type of technical knowledge is knowledge that is rational, theoretical, scientific, and universal. The best example is provided by the *Encyclopédie* of Diderot and d'Alembert. If the *Encyclopédie* appeared to be a powerful and dangerous work, the reason was not its attacks, whether veiled or blunt, on abuses and privileges, nor the "philosophical" nature of some of its articles; libels and pamphlets were available that were much more extreme than the *Encyclopédie*. What made the *Encyclopédie* formidable was that it was driven by an enormous force, the force of technical encyclopaedism, a force that won the support of powerful and enlightened patrons; this force had independent existence because, much more than political and financial reforms, it answered a need of the age; this positive and creative force established a remarkable grouping of researchers, of writers, and of correspondents, by giving a faith to a team of men who worked together without being linked by social or religious communities; the work to be done was important. The greatness and newness of the *Encyclopédie* reside in the fundamentally major character of its woodcuts of schemas and models of machines, which are a tribute to the crafts and to the rational understanding of technical operations. Now, these woodcuts do not play the role of being pure disinterested material for a public that wants to satisfy its

curiosity; the information to be found in them is complete enough to be useable practical material, so that everyone who owns the work [the *Encyclopédie*] should be able to construct the machine it describes or should use his invention and improve the technical situation already accomplished in that field, and should start his research from the point arrived at in the research of the men who preceded him.

The method and the structure of this new teaching are opposite to what preceded it: the new teaching is rational and doubly universal; that is why it is adult. It is rational because it uses the measurement, calculation, and procedures of geometrical representation and of descriptive analysis; rational also because it uses objective explanations, and it seeks experimental results, taking care to display its conditions precisely, treating as hypothetical what is conjectural, and treating as established fact what should be thought of as established fact; not only is scientific explanation required, it is required with a distinct commitment to the scientific mind. On the other hand, this teaching is doubly universal for two reasons, the public it addresses and the information it provides. The knowledge taught is on a really high level but still it is meant for everyone; only the cost of the work limits its possible sales. This knowledge is communicated in the spirit of the highest possible universality, according to a circular pattern that never assumes that a technical operation is closed in on itself in the secret of its own specialty, but that it is linked with others that use similar kinds of devices and are based on a small number of principles. For the first time, the establishment of a technical universe can be seen, a cosmos in which everything is connected to everything instead of being jealously guarded by a corporation. This consistent and objective universality, which assumes an internal resonance in the technical world, insists that the work should be open to everyone and that it should constitute a material and intellectual universality, a block of technical knowledge that is available and open. This teaching requires a subject who is adult, who is capable of self-direction, and who is able to establish his own standards without anyone directing him: the self-taught person is necessarily adult. A society of the self-taught cannot tolerate supervision or spiritual minority. It wants to be solely self-directing, to be self-managing. It is mainly in this sense and through its technological power that the *Encyclopédie* provided a new force and a new social dynamic. The causal circularity of encyclopaedic knowledge excluded the moral and political heteronomy of Ancien Regime society. The technical world discovers its independence when it achieves its unity; the *Encyclopédie* is a sort of Federal Holiday of technics that are discovering their solidarity for the first time.

III. -- THE COMMON NATURE OF MINOR AND MAJOR TECHNICS. THE MEANING OF ENCYCLOPAEDISM

We shall attempt to analyse the relationship of the encyclopaedic mind to the technical object, because it truly seems to be one of the poles of all technological knowledge and so to have, in addition to its historical importance, a sense that is always valid for an understanding of technicity. We have contrasted

the implicit, instinctive, and magical nature of technical education as it applies to the child with the opposite nature of these as we find them in the *Encyclopédie;* but such a contrast could obscure a profound analogy between the dynamisms in these structurings of technical knowledge; encyclopaedism demonstrates and promotes a sort of reversal of basic technical dynamics; however, this reversal is possible only because some operations are not so much destroyed as displaced and overturned in some way. The *Encyclopédie* also manipulates and transfers forces and powers; it casts an enchantment too and traces a circle resembling the magic circle; except that it does not cast an enchantment by the same means the ordeal uses in instinctive knowledge, and the reality it places within its circle of learning is not the same reality. Human society with its obscure forces and powers is what is placed within its circle, which has become immense and capable of encompassing everything. The objective reality of the book represents and constitutes the circle. Everything included in the encyclopaedic book is in the power of the individual who possesses this book, this symbol that includes all human activities in their most secret details. The *Encyclopédie* provides a universality of initiation, and by doing so produces a kind of explosion in the same sense as initiation does; the secret of the objectified universal retains the positive sense of the notion of the secret (fullness of knowledge and familiarity with the sacred), but reduces to nothing its negative character (obscurity, the use of mystery as a means of exclusion, the confining of knowledge to a small number of men). The technical becomes an exoteric mystery.[1] The *Encyclopédie* is an image (*un voult*) that is all the more effective for being made with a more precise and exact and objective representation of its model; all the active ingenuity, all the vital forces of human activities are brought together in this object-symbol. Every individual who can read and understand possesses the image of the world and of society. Magically, everyone is master of everything, because he possesses the image of everything. The cosmos, that in the past encircled the individual and was superior to him, and the constraining social circle which had always been so binding and eccentric to individual power, are now in the hands of the individual, like the globe representing the world that emperors carry as a sign of sovereignty. The power, the security, of the reader of the *Encyclopédie* is like that of the man who first attacked the effigy of an animal before accosting the animal in nature, and it is also like that of the primitive farmer who performed propitious rites before putting seed in the soil, or like that of the traveller who would not explore a new land until he had made it hospitable in some way by an act establishing a communion and a pre-possession, an act such as we remember from *The Odyssey* [2]. The rite of initiation is a union with reality, reality that remains hostile until it has been tamed and possessed. That is why every initiation makes the initiate manly and adult.

[1] Some of the feeling about the efficacy of primitive magic has developed into an unquestioning belief in progress. The modern or seemingly modern object has become clothed in an almost supernatural capacity for efficacy. The modern man's feeling retains some belief in the boundless and polyvalent power of a sacred *object*.

[2] The possession-of-the-earth rite Ulysses performs as he reaches the island of the Phaeacians.

Any manifestation of the encyclopaedic mind can therefore appear to be, from a psycho-sociological point of view, like a groundswell expressing a society's need to attain an adult and free condition, because the system or the customs of thought keep individuals in tutelage and in an artificial state of minority; in the history of thought since the Middle Ages, we find three recurrences of this desire to move from minority to majority by enlarging the circle of knowledge and by freeing the power to know. The Renaissance is the first manifestation of the encyclopaedic mind, and it is contemporary with the ethical and religious revolution of the Reformation. To want to go from the Vulgate to the true text of the Bible, to seek the Greek texts rather than being content with bad Latin translations, to rediscover Plato from beyond the Scholastic tradition that had become crystallized as fixed dogma, is to reject the arbitrary restriction of thought and knowledge. Erudition represent s not a return to the past as past, but the desire to enlarge the circle of knowledge, to rediscover the whole of human thought, in order to be freed from a restricting of knowledge.

Renaissance humanism is in no way a will to recover a fixed image of man in order to restrict and normalize knowledge, as the decline in classical studies today would seem to have us believe. Humanism is primarily an answer to an encyclopaedic enthusiasm. But this enthusiasm concentrated on already formalized learning because the level of technical development was not high enough to make possible a rapid formalization of this domain; the sciences especially were not well developed; intellectual means for universalizing technics were not yet available; it was the seventeenth century that brought with it the intellectual means for universalizing technology that the *Encyclopédie* implemented; however it should be noted that ever since the Renaissance a very positive attitude to technics is notable; already they are being thought of as valuable either as a paradigm and means of expression[3] or because of their human value in opening up new avenues. The magnificent eulogy that Rabelais makes about Pantagruel epitomises all the hope of Renaissance men, all their belief in the "vertu" [efficacy] of technics, thanks to which humanity will one day perhaps know how to travel to the outermost reaches of the heavens ["*jusque ès signes céleste*s"], just as it knew how to travel from the Old World to the New.

The second encyclopaedic stage is that of the century of the Enlightenment; scientific thought freed itself, but technical thought was not free; scientific thought was what set technical thought free. Because the technical infringes on commerce, agriculture, and industry, and because these are aspects of society, technological encyclopaedism could not avoid being the correlative of social and administrative reforms. Institutions such as Les Grandes Écoles arise from the encyclopaedic mind; encyclopaedism in its industrial aspect is by definition polytechnic, as it is physiocratic in its agricultural aspect. The industrial aspect advanced more than the physiocratic aspect, because encyclopaedic rationalization allowed for more sensitive changes in the industrial domain, which benefited from recent late eighteenth century scientific discoveries. However,

[3] In the *Deffense et Illustration de la Langue françoise*, Rabelais and Montaigne also use many terms drawn from crafts.

this asymmetric development should not make us forget one of the most important components of the encyclopaedic technical mind: namely, the direct connection of the individual with the vegetable and animal world, with biological nature; instead of being left to the descendents of the serfs of long ago, this technique of “the ploughman’s art” [<<*l’art aratoire*>] is highly valued even by the most distinguished personages. This was the age of the “sheepfolds” [<<*bergeries*>>] and the time when a mind as great as Daubenton’s does not hesitate to write a treatise to be used by shepherds, which is the prototype of the lofty and generous popularized book that continued the classical tradition of didactic works and that gave the tradition new life by using graphic symbolism that was clear and almost intelligible to the illiterate; the most important element in this beautiful book is its engravings, which are as clear and expressive as those of the *Encyclopédie*. Indeed, it is important to note that technology requires a means of expression different from oral expression, which uses already known concepts, and which can convey emotions, but which has difficulty in putting into words patterns of motion or precise physical structures; the symbolism appropriate to technical operation is visual symbolism, with its rich set of forms and proportions. The civilization of the word gives way to that of the image. Now, the civilization of the word is by its nature even more exclusive than that of the image, because the image is universal by nature, needing no established code of meanings. Verbal expression tends to become initiatory; it specialises in leading to a kind of coded language, of which the corporate jargons of long ago are a clear example. To understand oral or written language one must belong to a closed group; to understand schematic expression perception is enough. The schema, becoming truly universal, is what gives technical encyclopaedism all of its meaning and its power of diffusion. Printing had generated a primary encyclopaedism by circulating texts; but that encyclopaedism could reach only intellectual and emotional meanings that had been already sanctioned by established culture; by going by word from one person to another, information makes a detour through the social institution that is language. Printed writing, through the visual sign, conveys an oral message first of all, with all the inherent limitations of that mode of expression; the understanding of an encyclopaedism of verbal meanings requires a knowledge of all living languages and all ancient languages; having this linguistic accomplishment or, at least, trying to have such an accomplishment, is part of the importance of the Renaissance, but in actuality this was the prerogative of humanists and of the learned; through language, whether oral or written, culture does not have a direct universality. Perhaps that is the reason why the Renaissance was unable to set up a technological universality, despite its tendency, particularly in the arts, to prefer plastic and graphic expression to any other symbolism. Printing, a faculty for the diffusion of spatial design, finds its full meaning in engraving. So, symbolic engraving, used as a means of clearly conveying thought about structures and operations, free of any desire for allegorical expression in the direction of oral expression (like talking coats of arms), appears fully developed in the seventeenth century, in the treatises of Descartes, for example. Having borrowed its power of expression

and its capacity for preciseness from the practice of geometry, it is ready to be the appropriate symbolism of a universal technology.

Finally, a third stage of encyclopaedic thought seems to have started in our era, though it has not yet succeeded in establishing its modes of universal expression. The civilization of oral symbolism has once again overwhelmed the civilization of spatial, visual symbolism, because the new means of circulating information have given primacy to oral expression. When information has to be converted into an object that is printed and distributed, the delay separating discovered thought from printed thought is the same for written information and for figurative information. Printing privileges figurative information all the more because it has to use spatial form; the schema has no need of translation into a form other than its original form, whereas writing represents the translation into a spatial series of an originally time series, which will be converted once again into reading. As opposed to this, in information transmitted by telephone, telegraph, or radio broadcasting, the means of transmission makes necessary the translation of a spatial system into a time series, which is converted once again to a spatial system; radio broadcasting in particular is directly suitable for oral expression, and only with great difficulty can it be adapted to the transmission of a spatial system; it enshrines the primacy of sound. For this reason, spatial information is relegated to the domain of things that are expensive or rare, always lagging behind oral information, which is valued because it keeps pace with vital becoming (*le devenir vital*)[4]. So, civilization is guided by a latent paradigmatism regarding the information it values; this paradigmatism has once again become oral; thought is unfolded once more according to verbal semantic devices, for example the slogan. The active presence in inter-human relations is verbal in kind. Of course, we have the cinema and television. But we must remember that cinematography, precisely because of the dynamism of images, is more a cinematic and dramatic action than a written form of the simultaneous, and not directly an expression of an intelligible and stable form; following its discovery in the first test transmissions of images by television, it totally supplanted the latter and imposed on it the dynamism of images, which lays a heavy burden on television today, making it a competitor with and an imitator of cinematography, unable to discover its own modes of expression, and enslaved to the public as a provider of pleasure. Cinematographic motion has a powerful hypnotic quality and pace that soften the reflective faculties of the individual in order to bring him to a state of aesthetic participation. Organized as a time series that uses visual terms, the cinema is an art and means of expressing emotions; there the image is a word or a phrase, not an *object* with a structure that can be analyzed by the activity of the individual being; there the image is rarely an immobile and radiant symbol. Besides, television could become a contemporary means of information about human activity, something the cinema cannot be because, being something fixed and recorded, cinema consigns to the past whatever it incorporates. But, because television wants to be dynamic, it has to transform all the pixels [*tous les points*] of each image into a time series, in a time as short as it takes to project each static image in the cinema. So, first of all, it

[4] Or social. [Simondon's footnote]

transforms the dynamic to the static, because of a first cutting into images. Next, during the transmission of each fixed image, it transforms the fixed simultaneous pixels of the static image into a time series; the result is that each time series is immediately transformed into to an immobile spatial picture and, as in cinematography, the rapid succession of these fixed images re-creates the motion analyzed, because of the characteristics of the perception of motion. This double transformation answers the necessity of transmitting an enormous quantity of information, even for an image that is extremely simple in its intelligible structure. Here there is no common gauge to measure the disparity between the quantity of information that is really interesting and meaningful for the subject and the quantity of information used technically, amounting to many millions of signals per second. This waste of information prevents television from providing the individual with a supple and faithful means of expression and prevents a truly visual symbolism from being established universally; radio broadcasting crosses frontiers, whereas visual information often remains linked to the community life of groups; in these conditions it cannot be developed. But research on coding systems, which is useful for showing the results of the operation of calculators on a cathodic oscilloscope screen or for showing electromagnetic detection signals[5] on the same kind of screen, seems capable of bringing about a major simplification in the radio transmission of schematic images; so, in relation to spoken information, visual information would regain the place it lost to radio broadcasting and would be able to give rise to a new universal symbolism.

The encyclopaedic mind is beginning to appear in the sciences and in technics, in the trend towards rationalization of the machine and in the establishing of a symbolism common to the machine and to man; thanks to this symbolism the synergy of man and of machine is possible; because a joint action calls for a means of communication. And as man cannot have many kinds of thinking (every translation involving a loss of information), a new universal symbolism should be modeled on this combined relationship of man and machine in order to be consistent with a universal encyclopaedism.

In the theory of information cybernetic thought already provides research into subjects such as human engineering, which studies in particular the relationship between man and machine[6]; for that reason, it is possible to conceive of an encyclopaedism with a technological base.

This new encyclopaedism, like the two that preceded it, should lead to liberation, but of a different kind; it cannot be a repetition of that of the Enlightenment. In the sixteenth century man was a slave to intellectual stereotypes; in the eighteenth century he was restricted by hierarchical aspects of social rigidity; in the twentieth century he is a slave to his reliance on unknown

[5] In particular in R.A.D.A.R., *Radio Detection and Ranging* (the use of radio waves to locate and measure distance).

[6] Man today has a strong tendency that encourages him to act like a machine, a bearer of tools, because he performed this task through long centuries preceding the creation of machines, at a time when technical elements were in the form of tools, and technical assemblages were in the form of workshops and building sites, but were not technical individuals in the form of machines.

and distant powers which guide him without his knowing them and without his being able to react against them; isolation enslaves him and his lack of informational homogeneity alienates him. Having become a machine in a mechanized world, he can only regain his freedom by coming to terms with his role and transcending that role with an understanding of technical functions in terms of their universality. Every encyclopaedism is a humanism, if by humanism we understand the desire to go back to a condition of freedom that has become alien to the human being, so that nothing human would be foreign to man; but this rediscovery of human reality can happen in different ways, and every age recreates humanism in a manner that is always to some extent appropriate to circumstances of the age, because it aims at the most serious aspect of alienation that a civilization includes or produces.

The Renaissance defined a humanism that could offset the alienation caused by ethical and intellectual dogmatism; it aimed at recovering the freedom of theoretical intellectual thought; the eighteenth century sought to rediscover the significance of the effort of applying human thought to technics, and with the idea of progress it retrieved the loftiness of creative continuity to be found in inventions; it defined the right of the technical initiative to be, despite the inhibiting forces of societies. The twentieth century seeks a humanism that can compensate for the kind of alienation that takes place even within the development of technics, as a result of the specialization society demands and produces. It seems that there is a singular law in the development of human thought according to which every ethical, technical, or scientific invention that originally promotes the freedom and rediscovery of man, becomes, through historical evolution, an instrument that turns itself against its own end and enslaves man by restricting him: in its origins Christianity was a liberating force inviting man away from the formalism of customs and from the institutional illusions of ancient society.

According to that kind of thinking, the Sabbath was made for man and not man for the Sabbath; nevertheless, the Renaissance Reformers accused this same Christianity of being a force of rigidity, connected to formalism and to constraining dogmatism, contrary to the true and profound meaning of human life. The Renaissance contrasted Physis and Antiphysis. Likewise, the technologies which were hailed as liberating through progress in the age of the Enlightenment are today accused of subjugating man and of reducing him to slavery by denaturing him, by making him a stranger to himself through specialization which is a barrier and a source of incomprehension. The centre of convergence has become the principle of partition. That is why humanism can never be a doctrine or even an attitude that could be defined once and for all; every age needs to discover its own humanism, by guiding it towards the principal danger of alienation. In the Renaissance, the closure of dogma led to the dawn of a new fervour and a new enthusiasm.

In the eighteenth century, the endless fragmentation of the social hierarchy and of closed communities led to the discovery of a universal and non-mediate means of efficiency by the rationalization and the universalizing of the technical action, overcoming all the obstacles and prohibitions that had been

established by social manners. In the twentieth century, the hierarchical or local fragmentation of society is no longer the cause of the alienation of human society from man but, rather, its breathtaking, limitless, and changing immensity; the human world of technical activity has once again become alien to the individual, by developing and becoming formal and also by hardening in the form of a mechanization that once again joins the individual to an industrial world that exceeds the size of the individual and his capacity to think. The liberating technique of the eighteenth century is the right size for the individual because it is artisanal in kind. That of the twentieth century is beyond the forces of the individual, and in the industrial world is a human reality that is compact and durable, but alienated, and that is also as completely beyond the scope of the individual as a hierarchical society had been in times past.

Man no longer needs a universalizing liberation; mediation is what he needs. The new magic will not be found in the clear radiance of the individual power to act, assured by the knowledge that gives action effective certainty, but in the rationalization of those forces that put man in his place by making him significant in a human and natural unity. The singular fact of treating teleology as a knowable mechanism and not as definitively mysterious shows an unwillingness to suffer through and put up with a situation. Instead of looking for the process for manufacturing objects without making a pact with matter, man frees himself from the condition of being enslaved by the finality of it all by learning to construct a purpose by organizing a complete whole that he assesses and appreciates, as a means of avoiding having to submit passively to a de facto integration. Cybernetics, a theory of information and consequently also a theory of complete structures and dynamisms, frees man from the inhibiting restraint of the organization by enabling him to judge this organization, instead of subjecting himself to it while venerating it and respecting it because he is unable to imagine or understand it. Man oversteps subservience by consciously constructing what purpose is to be, just as in the eighteenth century he overcame the hapless necessity of work by thinking rationally about it instead of suffering with resignation in order to make work productive.[7] Human society, aware of its own teleological mechanisms, is a product of conscious human thought, and, as a consequence, incorporates those who constitute it; it is a product of human organisational effort, and it strikes a balance between being stuck with a position and finding a position for oneself. The position of man in a society becomes therefore a relation between an element of activity and an element of passivity, like a mixed status that can always be renewed and improved because it is separate from the human but not alien to the human. Consciousness is both a

[7] In the centuries gone by, an important cause of alienation lay in the fact that the human being lent his biological individuality to technical organization: he was a bearer of tools; the only way that technical ensembles were established was by using man as a bearer of tools. The distorting characteristic of his profession was both psychic and somatic. The bearer of tools was deformed by the use of tools. In our own day professional bodily deformities have become rare.

In the distaste that the man of breeding has for people in trade we may perhaps find a trace of the unpleasant feeling we have when we see a deformed person. Professional ills today are minimal in comparison with the deformities of ancient times. For Plato the *Banausos* is bald and dwarfish.
In musical legend, the little shoemaker is a being who is disadvantaged.

demiurgic activity and a product of an earlier organization; social reality is contemporaneous with human effort and homogeneous in relation to it. Only a scheme of simultaneity, a constellation of forces represented in their relational power may be appropriate to this kind of reality. A similar dynamic representation of man in society postulates its development; cybernetic schemes cannot find a universal meaning except in a society that is already constituted in a way that suits that kind of thinking; the most difficult reactivity to establish is the responsiveness of society to cybernetic thought itself; it can be established only progressively and through already established information channels, as for example exchanges between technics working synergistically on a given item; that is the kind of grouping that Norbert Weiner cites as a source of this new technology which is a technic of technics (*une technique des techniques*), at the beginning of his work entitled *Cybernetics.* This book was published in 1948; it is a new *Discours de la Méthode* (*Discourse on Method*), written by a mathematician who at the time was teaching in an institute of technology. Cybernetics gives man a new kind of majority that fathoms how authority affects the social body, and discovers beyond the maturity of reason a maturity of reflection which provides freedom to act and, in addition, by instituting teleology, provides the capacity to invent organization. Likewise, because purpose and organization can be thought of and invented rationally, they become materials for technics, and therefore they are no longer final and superior reasons that can justify anything: if purpose becomes subject to technics, purpose has an extension in ethics; in this sense, cybernetics frees man from the unquestioned illusion of the idea of purpose. Man used the technical to free himself from social constraint; by the technology of information, he becomes the creator of that organization of solidarity which had formerly imprisoned him; the stage of *technical encyclopaedism* can only be provisional; it calls for a stage of *technological encyclopaedism* that culminates in giving the individual the possibility of returning to the social body that is changing its status, and that is becoming the object of an organizational construction instead of being an acceptance of the given (*le donné*), whether valued or contested, that subsist with primitive characteristics outside of the activity of man. Thus, individual nature is no longer so much outside of the human domain. After access to liberty there follows access to authority in the full sense of the term and this is the authority of the creative force.

Such are the three stages of the encyclopaedic mind, which at first was ethical, and then technical, and which can become technological, by going beyond the idea of purpose as a final justification.

Now, we should not say that technics of a finalized organization are useful only because of their practical effects; they are useful in the sense that they remove purpose from the level of the magical to the level of the technical. Whereas the conjuring up of a higher end, and of the process that achieves this end, is considered to be the final term in the request for justification, [and] because life is confused with purpose in an age when technical schemes are only schemes of causality, the introduction into thought of technological schemes of purpose plays a cathartic role. Whatever has a technic cannot be a final

justification. Life, individual and social, has many aspects of completed processes, but purpose is perhaps no more the most profound aspect of either individual or social life, than the different modalities of the completed action, such as adaptation to a milieu.

Without doubt, it could be said that no genuine purpose informs the processes of recurrent causality to negative reaction; at the very least, this technical production of teleological mechanisms allows for the removal from the domain of magic of the lowest and crudest aspect of purpose: the subordination of the means to an end, thus, the superiority of end to means. Becoming technical matter, an organization of this kind is merely one of the aspects of social or individual life and can no longer conceal from its prestige the possibilities of the development, or advent, or sudden appearance of new forms, that cannot be justified by purpose since they produce their own end as the final term of evolution; evolution produces as many misfits as adaptations. That adaptations happen is just one aspect of life; homeostases are partial functions; technology, in enveloping them and in allowing them not only to be thought of but also to be made rationally real, leaves in full light the open processes of social and individual life. In this sense, technology lessens alienation.

IV. THE NECESSITY FOR A SYNTHESIS ON THE EDUCATIONAL LEVEL BETWEEN THE MAJOR MODE AND THE MINOR MODE OF ACCESS TO TECHNICS

The separation of the education of the adult and the education of the child in the field of technology depends on a difference in the structure of the two normative systems and, to some extent, on a difference in their outcomes. The consequence is that up to now there is an unbridgeable gap between pedagogical technology and encyclopaedic technology.

Encyclopaedic technological education aims to make the adult feel that he is an accomplished being, who is fully complete, in full possession of his capabilities and powers, the image of the individual man in the state of real maturity; the condition required for this feeling is the universality of right and of the fact of consciousness; now, something abstract remains in encyclopaedic education, and an irrepressible lack of universality: indeed, the material bringing together of all technical devices in a technological collection that gathers them by coordinating them as a simultaneous or rational system leaves aside what is temporal, successive, and quantum in the discoveries that have led to the way things are today; whatever in the present is progressively constructed and slowly and consecutively developed, is immediately seized upon; the idea of progress to the extent that it is mythic derives from this illusion of simultaneity, which presents as the real what is only a stage; because it excludes historicity, encyclopaedism introduces man to the acceptance of a false entelechy, because the stage in question is full of potentialities; invention has no presiding determinism, and, if progress is thought of as continuous, it conceals the very reality of invention. The self-educated person attempts to relate everything to the

present, making the past part of his current awareness, and thinking of the future as following continuously from the present by way of progress. The self-educated person has not been raised properly, that is, he has not become an adult in a progressive manner, through a timely series of developments shaped by crises that bring them to an end and allow for progress to another phase; one has to have grasped the historicity of technical becoming through the historicity of the becoming of the subject before adding to the order of the simultaneous that of the successive, in a form that is time. Genuine encyclopaedism, requiring temporal universality at the same time as the universality of the simultaneous, should integrate the education of the child; it can only become truly universal by forming the adult through the child, by pursuing temporal universality so as to arrive at the universality of the simultaneous; the continuity between the two forms of universality must be discovered.

Conversely, technological education lacks the universality of the simultaneous, that is to say it is more concerned with culture than with knowledge; but an enterprise that would want to attain culture by ridding itself of knowledge would be illusory, since the encyclopaedic order of knowledge is part of culture; hence, it can only be understood in an abstract and consequently non-cultural way if it is understood apart from knowledge itself. The representation of knowledge without knowledge itself is possible only by an understanding of an exterior symbol, as for example by means of the mythical and socialized representation of men who "embody" knowledge: knowledge is replaced by the figure of the wise man, that is to say, by a listed element of social or characterological typology that is utterly inadequate for knowledge itself, and introducing into culture a mystification that makes it inauthentic. At best, knowledge can be replaced by an opinion, a biography, a character trait, or a description of the persona of a scholar; but again these elements are totally inadequate because they are introductions not to knowledge but to idolatry of human pillars of knowledge, which is not of the same as knowledge itself. There is more authentic culture in the act of a child who reinvents a technical device than in the text where Chateaubriand describes that "fearsome genius" who was Blaise Pascal. We are closer to invention when we try to understand the cog-wheeled adding device used in Pascal's calculator (an arithmetic machine) than when we read the most oratorical passages about the genius of Pascal. To understand Pascal is to make a machine like his with one's own hands, not by copying it but by transposing it, if that were possible, into an electronic calculating device, in this way reinventing rather than reproducing, by updating Pascal's intellectual and operating schemes. To improve one's mind is to update real human schemes analogically, without being concerned except in a secondary manner with the incidental ripples that a particular invention or publication had among contemporaries, because these are inessentials, or at the very least they can only be understood by reference to the original idea, to the invention itself.

It is regrettable that a cultivated student in the final year of secondary school education knows Descartes' vortex theory only through the affectations of Bélise and the state of seventeenth century astronomy through "that long telescope to frighten people" which Chrysale cannot tolerate.

Here there is a lack of seriousness, a lack of truth in thought that can in no way be presented as culture. These evocations would be in their place if they could be situated in relation to their real source, understood immediately, and not through the pharisaism of a work of art that has different ends than culture. The encyclopaedic order of the simultaneous is expelled from cultural teaching because it does not conform to the opinions of social groups, who never have a representation of the order of the simultaneous because they represent only a minimal fraction of life in any specific age, and because they are unable to place for themselves. This hiatus between present life and culture derives from the alienation of culture, that is to say from the fact that culture is in reality an initiation to the thinking of specific social groups who had lived in earlier times; the primacy of letters in cultural education comes from that omnipotence of opinion; a [literary] work, and in particular a work that has survived, is in fact a work that has so well expressed the ethic of a group or of an era that the group in question is recognised in it; literary culture is therefore a slave to groups; it belongs to groups from the past. A literary work is a *social testimony*. Every aspect of didactic works is eliminated from culture, unless it is ancient and is considered to be evidence of a didactic "genre". Present culture pretends to think of the didactic genre as extinct in our time, whereas perhaps never in the past has there been so much expressive power, so much art, and so much of the human presence in scientific and technical writings. In reality culture has now become a genre with fixed rules and norms; it has lost its sense of the universal.

So to be completely educative, education needs human motivation. If we think in particular of the technical aspect of education and of encyclopaedism, we see that it is a very valuable mediator, because it comprises some aspects that make it available to the child and some others by which it fittingly symbolizes the successive states of scientific learning; indeed, the stumbling block that cultural education has battered itself against in trying to become encyclopaedic is this: it uses discursive intellectual symbols that make it difficult to understand the science we wish to know. As opposed to this, technical achievement provides scientific knowledge and uses it as a working principle in the form of a dynamic intuition that even a young child can understand, and that can become clarified more and more when coupled with a discursive understanding; genuine discursive knowledge admits no degrees; it is perfect right away or else false because inadequate. So, through technics, encyclopaedism could find its place in the education of the child, without demanding capacities for abstraction that the young child cannot fully satisfy. In this sense, the child's acquiring technological knowledge could lead to an intuitive encyclopaedism, understood through the nature of the technical object. As a matter of fact, the technical object differs from the scientific object in that the scientific object is an analytical object, which aims at analysing a single effect with all its conditions and its most specific characters, while the technical object, far from being completely placed in the context of a particular science, is actually at the meeting point of a multitude of scientific data and effects arising from a great variety of domains, integrating what seem like the most heterogeneous kinds of knowledge, and which cannot be coordinated intellectually, while they are coordinated in practice in the functioning of the

technical object; it has been said that the technical object arises from the art of compromise; indeed, it is eminently synthetic in structure, and cannot be understood other than by the introduction of a synthetic schematism governing its invention. The technical scheme, a relation between many structures and a complex operation that is achieved through those structures, is by its very nature encyclopaedic, since it completes a circularity of knowledge, a synergy of still theoretically heterogeneous elements of knowledge.

Perhaps it could be asserted that up to the twentieth century, technics were incapable of assuming the role of relating encyclopaedic work to the culture given to the child. Indeed, even then it was only with great difficulty that truly universal operations could be found within technics, including schematisms of feeling or of thought. Today the existence of technics of information provides technology with an infinitely greater universality. The theory of information puts technology at the centre of a great number of very different sciences, such as physiology, logic, aesthetics, phonetic or grammatical and even semantic studies of languages, numeric computation, geometry, the theory of group organisation and of systems of authority, probability theory, and all the spoken, sound, and visual techniques involved in broadcasting information. The theory of information is an interscientific technology that makes possible a systematization of scientific concepts as well as of the schematism of different technics; the theory of information ought not to be considered a technic among technics; in reality, it is a way of thinking that is the mediator between various technics on the one hand and between various sciences on the other, and further it is a mediator between the sciences and technics; it can play this role because there are connections between the sciences that are not only theoretical but also instrumental, technical, since each science can exploit for its purposes a number of other sciences, using them as technical sources to achieve the result of the experiment; there is a technical relation between the sciences; furthermore, technics can be theorized as a form of science; the theory of information has its place as a science of technics and a technic of the sciences, establishing a reciprocity of functions of exchange.

On this level, and only on this level, encyclopaedism and technical education can meet in a coherence of the two orders of universality, the simultaneous order and the successive.

We can say, therefore, that if up to the present day technics have produced two dynamisms that are not easily compatible, one of which is addressed to the adult and the other to the child, this antagonism carves out a position in the theory of information for a mediatory discipline which institutes continuity between specialization and encyclopaedism, between the education of the child and that of the adult. This is the basis for a reflexive technology transcending different technics, and defines a way of thinking that creates a relation between the sciences and technics.

The consequence of this reflexive unification of technics and of the ending of the opposition between theoretical learning and practical learning is significant for the reflexive notion of man; indeed, once this level has been reached, there is no longer a hiatus or an antagonism between the time of education and adult

age; the order of the successive and the order of the simultaneous become organized in a reciprocal relationship, and the time of the adult is no longer antagonistic to that of education. To a certain extent even, the evolution of societies, delayed until now by a determinism of youth, and then of maturity, and finally of old age, with corresponding political and social systems, should no longer be thought of as fatal if the perception of technologies is profound enough to introduce a system of references and values which is independent of that implicit biologism.

A careful analysis of dualisms in systems of value, such as the manual labourer- intellectual dualism, or that of farmer and city dweller, or that of child and adult, would show that basic to these differences there is a technical reason for the incompatibility between several groups of schematisms; the manual labourer is a person who lives with an intuitive schematism about material things; on the other hand, the intellectual is a person who has conceptualized palpable qualities; he lives in a way that stabilizes the order of the successive in definitions of man's nature and destiny; he derives a certain power from conceptualizing and enhancing or else demeaning the value of human acts and the values of life lived on the level of the intuitive. The manual labourer lives in the order of the simultaneous; he is self-educated when he wants to have access to a culture. The same difference in schematisms applies when the man from the country contrasts himself with the man from the city. The man from the country is contemporary with a set of requirements and involvements that make of him a being integrated into a natural system of existence; his leanings and intuitions are the bonds of this integration. The man of the city is an individual being, linked to social evolution rather than to a natural order. He contrasts himself with the man of the country in the same way as an abstract and cultivated being contrasts with an honest and uneducated being. The man of the city belongs to his time, whereas the man of the country belongs to the land; the former is part of the order of the successive, the latter of the order of the simultaneous. Generally speaking, we note that rural man is attached to traditions; but, to be precise, tradition is the most unconscious aspect of historicity, because it conceals the representation of the order of the successive, and it also assumes invariance in successivity. Real traditionalism is based on the absence of a representation of the sequence of becoming; becoming is ignored. Finally, the opposition between the child and the adult encapsulates these antagonisms; the child is the being of the successive, full of potentialities, changing with time, and aware of modification and change. The adult, who gives the child life, is integrated into society in the order of the simultaneous. Moreover, this maturity is fully attained only to the extent that society is stable and not evolving too quickly, without which a society that is undergoing transformation and privileges the order of the successive, exposes its adult members to a dynamism that makes adolescents of them.

Gilbert Simondon. On the Mode of Existence of Technical Objects

SECOND PART

Man and the Technical Object

CHAPTER TWO

THE REGULATORY FUNCTION OF CULTURE IN THE RELATIONSHIP BETWEEN MAN AND THE WORLD OF TECHNICAL OBJECTS. CURRENT PROBLEMS

I -- DIFFERENT MODALITIES OF THE CONCEPT OF PROGRESS

The attitude of the Encyclopaedists to the technics could be considered an enthusiasm provoked by the discovery of the technicity of elements. In fact, machines are not directly considered to be automata by the Encyclopaedists; rather they are considered to be an assembly of elementary devices. The attention of Diderot's collaborators focused on the elements of machines. In the eighteenth century, the technical ensemble is still of the same size as the workshop of the cork cutter or the pendulum maker; this ensemble connects with technical elements through the agency of the craftsman using tools or tool-machines, rather than through the agency of real technical individuals. That is why the division of materials to be studied is determined by rubrics of utility and not by technical schemes, that is to say according to types of machines; the principle for the grouping and analysis of technical beings is the name of the trade and not of the machine. Now, very different trades can use identical or near identical tools. This principle of grouping therefore leads to a certain redundancy in the presentation of tools and instruments that from one drawing board to the next can be very similar in form.

So, the principle of grouping by technical ensembles with an indeterminate plurality of elements is very closely linked to the idea of *continuous progress* as the Encyclopaedists conceived it. When technicity is understood at the level of elements, technical evolution is possible as a continuous line. There is a correlation between a molecular mode of existence in technicity and the continuous rate of the evolution of technical objects. A spiral, a screw thread was better cut in the eighteenth century than in the seventeenth; from a comparison of the same elements made in the seventeenth century and in the eighteenth century there emerged the idea of the continuity of progress as a step forward in what we have called the concretization of technical objects. This evolution of the element within already-constituted technical ensembles is not surprising: eliminating roughness, it improves the products of the manufacturing process, and gives the craftsman leave to continue using his customary ways of working, while giving him an impression that the work is easier; with more precise instruments, customary actions produce better results. To a great extent, the optimism of the eighteenth

century emerges from this elementary and continuous improvement in the conditions of technical work. In fact, anxiety arises from changes that cause a break in the rhythms of daily life by rendering useless the customary actions of days gone by. But improvement in the technicity of the tool plays a euphoric role. When man continues to enjoy the results of his apprenticeship while replacing an old-fashioned tool with a new one that can be used in the same way, he gets the impression that his actions are more precise, more efficient, and faster too. His whole corporal schema pushes back its boundaries, expands and is set free; his feeling of awkwardness diminishes: with a better tool, the trained man feels more adroit; he has more confidence in himself; for the tool is an extension of his body and is supported by action.

The eighteenth century was the great age in the development of tools and instruments, if by *tool* we mean the technical object which makes it possible to extend and equip the body to perform an action, and by *instrument* the technical object which makes it possible to extend and adjust the body to achieve better perception; the instrument is a tool of perception. Some technical objects are at once tools and instruments, but they can be called tools or instruments depending on whether the function is primarily active or primarily perceptive: a hammer is a tool, even though the receptors of our kinesthetic sensitivity and of our tactile vibratory sensitivity may enable us to perceive exactly the moment when a nail is hammered in too quickly and begins to bend or to crack the wood; in fact, to drive a nail in, the hammer must strike the nail in such a way that, when the job of driving in a nail is properly done, specific information is relayed to the senses of the man with the hammer in his hand; therefore the hammer is first of all a tool, since thanks to its function as a tool it can be used as an instrument; even when the hammer is used as a pure instrument, it is still first and foremost a tool: the mason recognizes the quality of a stone with his hammer, but for this the hammer must partially damage the stone. On the other hand, a telescope or a microscope is an instrument, and so are levels and sextants: these objects are used to collect information without having a prior action in the world. Now, the eighteenth century is the era when tools as well as instruments were manufactured with great care, benefiting from seventeenth century discoveries in both static and dynamic mechanics, as well as from discoveries in physical and geometrical optics. Marked progress in the sciences became translated into progress in technical elements. This accord between scientific investigation and its technical consequences is a new reason for the optimism that is added to the concept of progress, by spectacle of this synergy and the fecundity of the fields of human activity: instruments, improved by the sciences, are used in scientific investigation.

On the other hand, the appearance of technical evolution changes in the nineteenth century when complete technical individuals are invented. As long as these individuals are simply replacing animals, the disruption is not a frustration. The steam engine replaces the horse in the hauling of wagons; it powers the spinning mill; actions undergo change to some extent, but man is not replaced while the machine simply provides an improved use of energy sources. The Encyclopaedists were familiar with and celebrated the windmill,

which they described as a lofty and silent structure towering over the countryside. Many extremely detailed woodcuts feature advanced watermills. Man's frustration begins with the machine that takes the place of man, with the automatic loom, with forging presses, with the equipment in the new factories; in riots the worker breaks up machines, precisely because they are his rivals, no longer simply engines but bearers of tools; progress in the eighteenth century left the human individual intact because the human individual remained a technical individual among his tools, whose centre and whose bearer he was. Essentially what distinguishes the factory from the craftsman's workshop is not size, but change in the relationship between the technical object and the human being; the factory is a technical ensemble comprising automatic machines whose activity parallels human activity: the factory uses real technical individuals, whereas in the workshop it is man who lends his individuality to the performance of technical actions. Since then, the most positive and most direct aspect of the original concept of progress is no longer tried and tested. Eighteenth century progress is a progress that the individual felt in the force and rapidity and precision of his performance. Nineteenth century progress can no longer be felt by the individual, because it does not centralize him as the core of command and perception in the adapted action. The individual becomes a mere spectator of the results of machinery operations, or a manager of technical ensembles that make use of the machines. This is why the notion of progress splits, becoming anguished and aggressive, ambivalent; progress is remote from man and no longer has meaning for the individual man, because the conditions for man's having an intuitive perception of progress no longer exist; this implicit judgment, which is very close to kinesthetic impressions and to the facilitation of corporal energy that were the basis of the eighteenth century notion of progress disappears, except in fields of activity where the progress of the sciences and of technics bring about, as they did in the eighteenth century, an extension and a facilitation of individual conditions of action and of observation (medicine, surgery).

Progress, then, is thought of in a cosmic way, at the level of the products of the ensemble. It is thought of abstractly, intellectually, in a doctrinal way. Craftsmen no longer think about progress, but mathematicians do so, conceiving of progress as man's a taking possession of nature. The idea of progress supports the technocratic system, with the Saint-Simonian movement. An idea of progress that is conceptual and deliberate replaces the impression of progress as something experienced. The man who thinks about progress is different from the working man, except in rather rare cases, for example that of printers and lithographers, who for the most part have continued to be craftsmen. Even in these cases, the rise of the machine led people who thought deeply about its nature to hope for a transformation of social structures. One might say that in the eighteenth century work and technicity were linked in the testing of elementary progress. As opposed to this, the nineteenth century brings about a separation of the conditions for understanding progress and of the testing of internal rhythms of work resulting from this same progress. The nineteenth man did not examine progress as a worker: he did so as an engineer or as a user. The engineer, *l'engénieur*, the man of the machine, actually becomes the manager of the

ensemble that consists of workers and machines. Progress is thought of as a movement significant because of its products and not in itself in the ensemble of operations that constitute it, in the elements that establish it, and it is valid for a crowd, coextensively with humanity.

Poets at the end of the first half of the nineteenth century felt that progress was a general advancement of humanity, with its burden of risk and anxiety. This progress has something in it along the lines of an immense collective adventure, of a voyage too, and even of a migration towards another world. This progress has about it something both triumphant and crepuscular. Perhaps that is the word Vigny, in *La Maison du Berger*, sees written above cities. This feeling of ambivalence toward the machine is found in the reaction to the locomotive and to the compass, the former in *La Maison du Berger,* the latter in *La Bouteille à la Mer*. The latter poem shows how Vigny felt the transitional character (transitional because contradictory, perhaps) of progress in the nineteenth century. This idea of progress as unfinished and imperfect contains a message for posterity; it cannot be complete in itself. One of the aspects of *Destinées* is that living this moment in technical evolution is something we must accept. Vigny made it true and meaningful by understanding that he could not be self-sufficient, self-secure.

A third aspect of the concept of technical progress appears with the impact of internally self-regulating technical individuals on technical ensembles, and, through these ensembles, on humanity. The second stage, which coincided with the arrival of the new technical wave at the level of individuals, was characterized by ambivalence in progress, by the dual situation of man regarding the machine, and by producing alienation. Marxism understood that the relationship between the worker and the means of production was the origin of this alienation, but in our opinion alienation does not emerge solely from a relationship of ownership or non-ownership to the worker and the instruments of work. Beneath this legal and economic relationship with ownership there exists an even more profound and more essential relationship, that of the continuity between the human individual and the technical individual, or of the discontinuity between these two beings. Alienation does not emerge solely because in the nineteenth century the human individual as a worker is no longer the owner of his means of production, whereas in the eighteenth century the craftsman was the owner of his instruments of production and of his tools. Alienation emerges when the worker is no longer the owner of his means of production, but it does not emerge exclusively because of the severing of the link with property. It emerges also outside of any collective relationship with the means of production, at a strictly individual, physiological and psychological level. The alienation of man from the machine has more than a socio-economical meaning; it also has a psycho-physiological meaning; the machine no longer extends corporeal experience to workers or to those who own the machines. The bankers whose social role was exalted by mathematicians such as the Saint-Simonians and Auguste Comte are just as alienated from the machine as are the members of the new proletariat. By this we wish to say that there is no need to postulate a master and slave dialectic to account for alienation in the propertied classes. The relation of ownership with regard to the machine involves as much alienation as the non-ownership relation,

even though it pertains to a very different social state. On both sides of the machine, above and below, the man-of-elements who is the worker and the man-of-ensembles who is the industrial employer lack a true relationship with the individualized technical object in the form of the machine. Capital and labor are two modes of being that are equally imperfect in relation to the technical object and to the technicity contained in industrial organization. Their apparent symmetry does not in any way mean that the meeting of labor and capital reduces alienation. The alienation of capital is not alienation in relation to labor, in relation to contact with the world (as in the master and slave dialectic), but precisely in relation to the technical object; the same goes for labor: what labor lacks is not what capital possesses, and what capital lacks is not what labor possesses. Labor has an understanding of elements, and capital has an understanding of ensembles; but bringing together the understanding of elements and the understanding of ensembles does not create an understanding of the *intermediary and unmixed* being which is the technical individual. Element, individual, and ensemble follow one another on a temporal line; the man-of-elements slow in relation to the individual; but the man-of-ensembles who has not understood the individual is not ahead in relation to the individual; he tries to fit the technical individual of today into the structure of an ensemble that belongs to the past. Labor and capital are behind the times in relation to the technical individual, the guardian of technicity. The technical individual does not belong to the same time as the workforce that operates it and the capital that frames it.

Labor-capital dialogue is false because it is a thing of the past. The collectivization of the means of production cannot on its own cause a reduction of alienation; it can have this effect only if it is the precondition for the human being's acquiring an understanding of the technical object as individual. To establish this relation of the human individual to the technical individual is a remarkably delicate task. It requires a technical culture, one that introduces a capacity for attitudes that are different from the attitudes of labor and of management (labor corresponding to the understanding of elements and management corresponding to the understanding of ensembles). Labor and management have in common the predominance of finality over causality; in both cases, effort is directed towards a certain predetermined outcome; the means used are in a minority situation compared to the result: the plan of action counts less than the result of the action. In the technical individual on the other hand, this disequilibrium between causality and finality disappears; externally, the machine *is constructed* to bring about at a certain result; but the more the technical object is individualized, the more this external purpose becomes effaced in favor of internal functional coherence; the functioning is finalized in relation to itself before being finalized in relation to the external world. Such is the automatism of the machine, and such is its self-regulation: at the level of regulation there is functioning, and not only causality or finality; in self-regulated functioning, all causality has a sense of finality, and all finality has a sense of causality.

II. —A CRITIQUE OF THE RELATIONSHIP BETWEEN MAN THE TECHNICAL OBJECT IN THE LIGHT OF THE CONCEPT OF PROGRESS IN THERMODYNAMICS AND ENERGETICS. AN APPEAL TO INFORMATION THEORY

Man's intuition about the schemes of functioning is what makes it possible for him to relate to the individualized technical being; man can be coupled with the machine as one equal with another, as a being who participates in its regulation, and not only as a being who directs it or makes use of it by incorporating it into ensembles, or as a being who serves it by providing materials and elements. By this we mean to say that neither an economic theory nor an energetic theory can account for such a coupling of man and machine. Energetic or economic linkages are too external to be useful in defining this real coupling. There is an interindividual coupling between man and machine when the same self-regulating functions are better and more efficiently accomplished by the man-machine couple than by man alone or the machine alone.

Let us take the case of what we call memory. Leaving aside all the mythological assimilations of vital functions to artificial operations, we can say that man and machine present two complementary aspects of the use of the past. The machine is able to retain very complex, detailed, precise monomorphic documents for a very long time. An audiotape three hundred meters long can keep a recording of the magnetic translation of any noise or sound in the range of 50 to 10,000 Hz, corresponding to about an hour's listening-time, or two hours if one accepts a reduction of the frequency band to 5,000 Hz. A roll of film of the same size can record scenes that take about half an hour to play, with a definition of about 500 lines, that is to say in a way that makes it possible to distinguish about 250,000 pixels[1] on every image. So, the audiotape can record 3,600,000 sonic events each distinct from the others; cinematographic film-stock [can record] 120 million pixels each distinct from the others. (The difference in these figures does not derive from the fact that the grain of a magnetic strip is larger than that of the sensitive film; in fact, it is of the same size; it comes primarily from the fact that the recording of sound corresponds to a linear track on a tape, whereas the recording of images corresponds to a division of successive surfaces in which almost every one of the sensitive pixels can become a carrier of information.) But what characterizes the conservation function of the machine here is that it is absolutely without structure; film does not record clear-cut figures, geometrical images for instance, any better than the disordered image of grains in a pile of sand; to a certain extent even, vivid contrasts of clear-cut surfaces are recorded less effectively than the disordered uniformity of the grains of sand because of the phenomena of light diffusion in film stock, which creates the so-called halo effect around well-lit and clearly delineated areas. Similarly, the audiotape does not record continuous and well-formed musical sounds any better than transitional tones or noises: record-keeping by a machine has no order, because the machine has no ability to select forms. Human perception distinguishes forms, perceptual units, when looking at or listening to

[1] Translator's note: Simondon, writing before the coining of the word pixels, uses "*points*" here.

recorded documents. But the recording itself does not really include these forms. The incapacity of the retentive function of machines relates to the recording and reproduction of forms. This incapacity is general; it exists at every level. Considerable intricacy is needed to make it possible for a calculator to write results in clearly-legible figures on a cathode-tube screen. The *numéroscope* is made of very delicate and complex montages, using encodings to find lines that somehow reproduce numbers. It is far easier to produce Lissajous figures than to write the number 5. The machine cannot retain forms, but only a translation of forms, by means of an encoding in a spatial or temporal distribution. This distribution may be very durable, like that of the audiotape, and definitive, like that of silver grains in sensitive film, or altogether provisional, like that of the pulse train in transit through a mercury column with a piezoelectric crystal at each end, used in certain types of calculators for the preservation of partial results in the course of operation; it can also be very fleeting but maintained, as in the case of the recording of numbers on a mosaic in a certain type of cathode-ray tube somewhat like the iconoscope, and equipped with two electron guns, one for reading and inscription, the other for upkeep (cf. the Massachusetts Institute of Technology RCA selectron and storage-tube). The plasticity of the support must not be confused with the real plasticity of the recording function; it is possible to erase in a thousandth of a second the numbers inscribed on the beryllium mosaic of the selectron and to replace them with others: but the speed with which successive recordings succeed each other on this same medium in no way means that the recording is itself plastic; each recording, taken in itself, is perfectly rigid. It is obviously possible to erase the magnetization of the oxide grains in the audiotape and to record anew. But the new recording is completely separate from the preceding one; if the first is poorly erased, it interferes with the next recording, blurring it, rather than facilitating it.

In human memory, on the other hand, what is retained is the form: retention is a very restricted aspect of memory, which is the power of selecting forms, of schematizing experience. The machine would be incapable of performing a similar function unless the already-recorded tape was better than a new tape at recording some sound figures, which is not the case. Plasticity in the memory of machines is that of a support, whereas in human memory it is the plasticity of the content itself.[2] One can say that in man the function of retaining recollections is in the memory, because memory, conceived as an ensemble of forms, of patterns, welcomes and preserves recollection because it links it to its forms; as opposed to this, recording in a machine is made with no prior memory. For human memory the result of this essential difference is an important incapacity to remember elements that have no order. It would take a very long time to learn the relative position of fifty colored chits and various other different forms emptied willy-nilly on a table;

[2] An unused magnetic tape is equal to or better than an already used tape if the same form is registered many times in succession. A cathode ray tube on which the same image is continually projected far from becoming better able to register it, loses its sensitivity in areas occupied by the image, so much so that after prolonged use it is more sensitive to new images, which do not form in the same points as the older ones.

even an out-of-focus photograph would be better than a human witness when it comes to affirming the relative position of various objects in space. Machine memory triumphs in multiplicity and disorder; human memory triumphs in order and in the unity of forms. Every time a function of integration or comparison appears, the most complex and best-built machine provides results that are considerably inferior to those that human memory can provide. A calculator can be programmed to translate, but its translation remains very elementary and crude. It requires a prior reduction of each of the two languages to a simplified basis, along with a reduced vocabulary and set turns of phrase. For what the machine lacks is the plasticity of integration, the vital aspect of [human] memory that makes it instantly distinct from machine memory: the "*storage*"[3] of the calculator or the translating machine (which is just a classical calculator programmed in a special way) is very different from the function of the present by which memory exists in man at the level of perception, [and by which] through perception it gives meaning to the spoken word according to the general turn of phrase and of earlier phrases, or even according to the totality of past experience one has had with the speaker's subject. Human memory receives contents that have a formative power in the sense that they overlap, are grouped, as if acquired experience served as the code for new acquisitions, to interpret them and define them: *content becomes coding* for man and more generally for the living, whereas in the machine coding and content remain separate as condition and conditioned. Content introduced into human memory will impose itself on earlier contents and take form [from them]: in the living the *a posteriori* become *a priori*; memory is the function by which *a posteriori* matters become *a priori*.

Now, a complex technical operation requires the use of both forms of memory. Non-living memory, machine memory, is useful in cases where precision in the retention of details outweighs the syncretic nature of remembrance integrated into experience, because it has meaning through its relation with other elements. Machine memory is that of the document, of the result of measurement. Human memory is that which, after an interval of many years, recalls a situation because it involves the same meanings, the same sentiments, the same dangers as another, or simply because this similarity has a meaning according to the implicit vital coding that constitutes experience. In both cases memory allows self-regulation; but human memory makes self-regulation possible according to a set of meanings that are valid in the living and that can develop only in the living; machine memory establishes a self-regulation that has meaning in the world of non-living beings. The meanings according to which human memory functions come to a stop at the point where those used by machine memory begin.

The coupling of man and machine begins from the moment when a coding common to both of these memories can be discovered, so that a partial convertibility of one into the other can occur, for a possible synergy. One case of this coupling is provided by the permanent data file of telephone calls. The summarized information recording up-to-date results obtained from multiple domains classed under different rubrics is registered on magnetic tapes. A

[3] An English term meaning *put in reserve*.

catalogue and a telephone call record make it possible to use selectors to quickly get a read-out of what has been recorded on any one of the magnetic tapes. Here human memory finds meaning in the columns of names and words. On the other hand, the machine is provoked by a specific pulse train to power one magnetic plate reader and not another: this fixed and rigid faculty for selection is very different from the one that prompts the enquirer to dial one particular phone-number rather than another. Now, this sheer coupling of machine and man makes it possible to understand the mode of coupling in other cases: coupling occurs when a single and complete function is carried out by the two beings. Such a possibility exists whenever a technical function includes a defined self-regulation. Self-regulating functions are those in which the completion of a task is directed not only by a model to be copied (according to a purpose) but by the partial result of the completion of the task, intervening as a condition. In the artisanal process, this control through information-gathering is common; since man is at once a tool-user and a perceptive subject, he regulates his action according to partial, instantaneous results. The tool is both tool and instrument, that is to say, a means of action extending the bodily organs and a channel of recurrent information. As opposed to this, the machine as a closed, complete individual replacing man generally does not have a system of self-regulation: it unrolls a stereotypy of successive actions according to a predetermined conditioning. This primary type of machine is one we can call a mechanical being without self-regulation. It is no doubt a practical technical unit, but strictly speaking it is not a technical individual.

On the other hand, and despite appearances, the truly automatic machine is the one least likely to replace man successfully, because there is a regulatory function in this machine that requires variability in its running, a functional adaptability to complete the work. A very elementary enthusiasm for self-regulating automata obscures the fact that these machines are precisely the ones that are most in need of man; whereas other machines need man only as servant or as organizer, self-regulating machines need man as technician, that is to say, as an associate; their relation to man is at the level of this regulation rather than at the level of elements or of ensembles. Yet it is by this regulation that automatic machines can be linked to the technical ensemble in which they function. Just as the human individual is linked to the group not by his elementary functions, whether active or perceptive, but by the self-regulation that gives him his personality and character, so the machine is integrated with the ensemble not only in an abstract and prefatory way by its function, but also, at every moment, by the way it performs its own task as a function of the requirements of the ensemble. There is no purely internal, entirely isolated, self-regulation; the results of the action are results not simply in themselves but also in their relation to their external milieu, the ensemble. Now, this aspect of self-regulation in which *the whole of the milieu must be taken into account* cannot be achieved by the machine alone, even if it is very perfectly automated. The type of memory and the type of perception suited to this aspect of regulation call for the integration, the transformation of the *a posteriori* to the *a priori* which only the living can achieve on its own. There is something alive in a technical ensemble, and the integrating of life can be

guaranteed only by human beings; the human being has the capacity to understand the functioning of the machine, on the one hand, and the capacity to live, on the other: one could speak of technical life as that which succeeds in achieving in man the connection between these two functions. Man is able to assume the relation between the living being that he is and the machine that he constructs; technical operation necessitates a life that is both technical and natural.

Now, technical life does not consist in running machines, but in existing at the same level, as a being assuming the connection between them and capable of being coupled simultaneously or successively with several machines. Each machine can be compared to a monad, a thing isolated. The capabilities of the machine are not those that have been put in it by its manufacturer: it reveals its properties as the substance develops its attributes. The machine is the consequence of its essence. On the other hand, man is not a monad, since in him the *a posteriori* becomes *a priori*, the event a principle. The human technician does not perform this function before the manufacture of the machines, but during their operation. He guarantees this function, maintaining the correlation because his life is shaped by the rhythms of the machines that surround him and that he links one to the other. He provides the function of integration and extends self-regulation beyond each monad of automatism by the interconnection and intercommunication of the monads. The technician is in a certain sense very much the man of ensembles, but in a very different way from the industrialist's. The industrialist like the worker is driven by finality; he aims at results; their alienation lies in this; the technician is the man of the operation that is under way; he assumes not the direction but the operational self-regulation of the ensemble. He absorbs into himself the sense of the work and the sense of its industrial direction. He is the man who knows internal schemes of operation and organizes their interrelationship. Machines on the other hand are unaware of general solutions, and cannot resolve general problems. Whenever it is possible to replace a complex operation by a greater number of simple operations, this is the procedure used in the machine; this is the case with calculators that use a binary system of numeration (rather than a decimal system) and reduce all operations to a series of additions.[4]

One can affirm in this sense that the birth of a technical philosophy at the level of ensembles is possible only through an in-depth study of regulations, which is to say of information. Real technical ensembles are not those that make use of technical individuals, but those that are a tissue of technical individuals in an interconnected relationship. Any technical philosophy that deviates from the reality of ensembles by making use of technical individuals without linking them to information is a philosophy of human power through technics rather than a philosophy of technics. We could use the term autocratic philosophy of technics for a philosophy that takes the technical ensemble to be a place where machines are used for power. The machine is only a means; its end is the conquest of nature, the domestication of natural forces by means of a primary enslavement: the machine is a slave that is used to make other slaves. A similar enslaving and

[4] Basic life processes are on the contrary processes of integration.

domineering inspiration can be encountered with a petition for the liberty of man. But it is difficult to make oneself free by transferring slavery on to other beings, whether men, animals or machines; ruling over a population of machines that reduce the entire world to slavery is still ruling, and all ruling assumes the acceptance of schemes of enslavement.

Technocratic philosophy is itself affected by an enslaving violence, as it is technocratic. The technicism emerging from a reflection on autocratic technical ensembles is inspired by a will to unbridled conquest. It is inordinate, lacking internal regulation and self-mastery. It is a force that lasts and that lasts only while its rising phase of success, of conquest, endures. Saint-Simonianism triumphed under the Second Empire because there were wharfs to construct, railways to open up, bridges and viaducts to build over valleys, mountains to bore tunnels through. This conquering aggression is characterized by a rape of nature. Man takes possession of entrails of the earth, ploughs through it, and steps over what had been impassible until today. So, in a sense, technocracy is guilty of a violation of the sacred. To build a bridge over an arm of the sea, to link an island to the mainland, to cut through an isthmus, is to change the configuration of the earth, is to violate its natural integrity. In this violence there is a pride in dominating, and man gives himself the title of creator or at least the foreman of creation: he plays a demiurgic role: this is Faust’s dream, now taken up by the whole of society, and by all technicians. In fact, the development of technics is not enough to explain the birth of technocratism. Technocratism represents the will to attain power that emerges in a group of men who have knowledge but no power, who have knowledge of technics but do not have the money to implement them, or the legislative power to be freed from constraint. In France technocrats are essentially polytechnicians, that is to say men who, in relation to technics, are in the situation of intelligent users and organizers rather than real technicians. These mathematicians think in sets rather than in individual operational units; what holds their attention is not so much the machine as business.

Furthermore, and fundamentally in an even more profound manner, psycho-social conditioning is complemented by conditioning that comes from the state of technics. The nineteenth century could produce only one technocratic technological philosophy because it discovered engines and not control instrumentation [*les régulations*]. It is the age of thermodynamics. Now, an engine is in some sense very much a technical individual, because it cannot function without including a number of regulators or at the very least automatisms (intake, exhaust); but these automatisms are auxiliary; their function is to make possible a recommencement of the cycle. Sometimes, the addition of real self-regulators such as the Watt's *governor* (a centrifugal regulator called a ball valve) to fixed machines individualizes the heat engine in a very complete way; however, regulators still remain accessories. When a heat machine has to generate great momentum in accordance with a system that is extremely intermittent it is good to have an alert man standing by it who can press the regulator-lever to prevent overload, because if the regulator worked for too long a time it would run the risk of intervening when the engine would have already slowed down because of sudden load increase: this is what happens when a steam-engine is used to cut

large tree trunks into planks; without human intervention, the wheel of the saw has already stalled, or the belt has already fallen, once the regulator kicks in; the worker hits the regulator-lever a half-second before the saw-wheel cuts into the trunk: the engine is therefore running at full power and is in the process of accelerating when the load suddenly increases. On the other hand, the Watt regulator is extremely efficient and precise when it comes to slow and cumulative load variations. A similar incapacity for rapid variations can be explained by the fact that, in thermodynamic engines, even when there is a self-regulation, this self-regulation has no information-channels that are separate from the effectors. There is in fact a feedback[5] valve in the Watt *governor*, but this is not distinct from the power valve, which allows the engine to move a resistant body: the regulator is connected to the output shaft; so the whole ensemble that is made up of fly-wheels, main shaft, the volumetric cylinder device, and the system for transforming alternating movement into circular movement, must already have slowed down by losing its kinetic energy so that the regulator intervenes by increasing the admission-time of the engine, consequently increasing its power. Now, there is a serious drawback in this indistinctness of the power valve (the energy channel) and the reactive valve (the information channel), that greatly reduces the effectiveness of regulation, and the extent of the individualization of the technical being: when the engine slows down (a necessity for regulator activity), the decrease in running speed causes a decrease in power (engine power, with low or medium speeds which do not need the lamination of steam in the valve is proportional to the sum of all the elementary work done in a unit of time by successive piston strokes). The decrease in angular speed causes deterioration in the very conditions of the renewal which the regulator is designed to promote.

This indistinctness between the energy channel and the information channel is what marks the thermodynamic era and constitutes the limit of the individualization of heat engines. Let us suppose, on the other hand, that at every moment a gauge measures the motion of the transmission-shaft at the outlet of a heat engine, and that the result of this measurement is sent back to steam-intake (or gasoline-intake or carbureted air-intake if it is an internal combustion engine), so as to increase steam-intake in relation to the increased resistance exerted on the transmission-shaft; so, the pathway by which the resistance measurement ascends to the steam-supply and modifies it is distinct from the energy channel (steam, cylinder, piston-rod, crank-shaft, axle, transmission-shaft): to increase its power the engine does not need to slow down: the information recurrence time along the information-channel can be extremely short in terms of the time constants of the energy-channel, for instance a few hundredths or a few thousandths of a second, whereas a fixed steam-engine cycle lasts about a quarter of a second.

It is therefore natural that intervention in the use of information-channels distinct from energy-channels in engines caused a very profound change in techno-philosophy. This accession was conditioned by the development of vehicles of information, particularly low current. This is what we call electric currents that are not thought of as energy carriers but as vehicles of information.

[5] Simondon writes : «une voie de contre-réaction (*feedback*) »

The electric current as a vehicle of information has no equal except for radio waves or a beam of light, which also is made of electromagnetic waves such as radio waves: what the electric current and the electromagnetic wave have in common is an extreme speed of transmission and the capacity to be modulated with great precision, without appreciable inertia, in frequency and amplitude. Their capacity to be modulated makes them accurate carriers of information and their speed of transmission makes them rapid carriers. What becomes important then is no longer the power conveyed, but the precision and accuracy of the modulation transmitted by the information channel. Beyond the dimension defined by thermodynamics a new category of magnitude emerges that makes it possible to classify information channels and to compare them. This development of new concepts has meaning for philosophical thought by providing the example of new values which until our day had no meaning in technics, though they had meaning in human thought and behavior. In this way, thermodynamics had defined the notion of efficiency for a conversion system such as an engine: the efficiency is the relation between the amount of energy at the inlet of the engine and the that collected at the outlet; between the inlet and the outlet there is a change in energy form; for example, in the case of the heat engine, thermal energy becomes mechanical energy; since we know the mechanical equivalent of a calorie, we can define the efficiency of an engine as a transformer of thermal energy into mechanical energy. More generally, in every device that performs a conversion, we can define an efficiency that is the relationship between two energies; in this way there is a performance home, the relationship between the chemical energy represented by the ratio between the amount of chemical energy contained in the fuel system and the amount of heat actually released; an efficiency of the home-boiler system, defined by the relationship between the caloric energy produced by the furnace and the thermal energy actually transmitted to the water in the boiler; there is an engine efficiency which is the relationship between the energy contained in the system composed of the hot steam sent to the inlet and the cold source in the tailpipe, and the mechanical energy actually produced by its reduction in pressure in the cylinder (a theoretical efficiency governed by the Carnot principle). In a series of energy-transformations, the efficiency calculated between the initial inlet and the final outlet is the product of all the partial efficiencies. This principle is even applicable in the case where the energy recorded at the outlet is of the same nature as that at the inlet; when a storage battery is charged, there is an initial partial efficiency which is the conversion of electrical energy into chemical energy; when it is discharged, there is a second partial efficiency, which is that of the conversion of chemical energy into electrical energy: the efficiency of the battery is the product of these two efficiencies. However, when an information channel is used to transmit information, or when information is recorded on a support for retention purposes, or again when there is a transfer from one information-carrier to another support (for example from mechanical vibrations to an alternating current in which the frequencies and amplitudes follow the vibrations), a loss of information occurs: what is collected at the outlet is not identical to what was at the inlet.

For example, if one wants to transmit a current of acoustic frequencies through an information channel that is a telephonic circuit, one notes that some frequencies are correctly transmitted: for these, the modulation collected at the output is identical to that which was put in at the input of the circuit. But the bandwidth of the telephone circuit is narrow; if one enters a noise or a complex sound at the entrance to this channel a considerable deformation ensues: the modulation collected at the output is in no way comparable to that which was entered at the input; it consists in a depletion of the former; for example, the fundamentals of complex sounds between 200 Hz and 2000 Hz are transmitted correctly but deprived of their upper harmonics. Or yet again, the circuit introduces a harmonic distortion, which is to say that a sinusoidal sound entered at the input is no longer represented by a sinusoidal tension at the output; despite their apparent difference, the two phenomena are nevertheless the same: the circuit that introduces a harmonic distortion is a characteristically narrow information channel that would transmit without appreciable distortion a sound that at the input has the harmonic frequency that appears at the output-- even when it was not at the input--when the circuit has a resonance at this harmonic frequency. A perfect information channel would be one that at the output gives all the modulations, rich or complex as they may be, as had been put in at the input. One could assign to it a performance equal to 1, as to a perfect engine.

These efficiency characteristics of information-channels are not energy characteristics, and very often good information efficiency goes hand-in-hand with low energy efficiency: an electromagnetic loudspeaker has better energy efficiency than an electro-dynamic loudspeaker, but very poor information productivity. This fact is fairly well explained if one considers that, in a transformation system, the best energetic efficiency is obtained when there is a tight coupling of two elements by a high-pitched resonance; a transformer whose coil capacities are in tune with a certain frequency has an excellent primary-secondary coupling for this frequency; but it has a poor coupling for other frequencies: it therefore transmits this frequency selectively, which causes a considerable signal loss when it is being used for broadband transmission; a transformer designed to transmit information has a lower energy efficiency, but constant for a wide frequency band. So, energy efficiency and information efficiency are not two magnitudes linked one to the other: the technician is often obliged to sacrifice one of the two efficiencies to get the other. What is what is essential in information channels, and the conditions for its correct transmission are very different from those in the transmission of high-energy output. Solving problems related to information channels calls for a mental attitude different from what is appropriate to problem solving in applied thermodynamics.[6] The thermodynamics technician favors colossal buildings and large scale effects, because thermodynamic outputs increase with the size of engines and installations. It is certainly possible to construct a small-scale steam-engine, but the efficiency gained is low; even if it is very well constructed, it cannot attain an excellent efficiency because heat loss and the importance of mechanical friction come significantly into play. The turbine is a system for transforming thermal energy into mechanical energy, which provides better efficiency than does

[6] Or more generally energy.

a reciprocating engine; but if a turbine is to function in good conditions, it requires a large installation. The output of three small thermal power plants is lower than that of a single power plant with the same power as the three small ones together. This increase in output with the dimensions of the machines in play is a general practical law of energy that is beyond the scope of thermodynamics properly so called; an electric industrial transformer has, in general, better productivity than that of a transformer of fifty watts of rated power. However, this tendency is much less marked in new forms of energy, such as electric energy, than in old forms of energy, for example heat; nothing would stand in the way of the construction of a high-efficiency small scale electric transformer; if the efficiency of low-power devices is to some extent disregarded, it is because a loss of efficiency is less serious for them than for industrial devices (heating, in particular, is more easily dissipated, for the same reasons that a small steam-engine has lower efficiency than a large one).

On the contrary, the information technician is likely to look for the smallest possible dimensions compatible with the residual thermodynamic requirements of the devices he uses. In fact, the information is all the more useful in a regulation the less time it takes. Now, an increase in the size of machines or of information-transmitting devices increases inertia and transit time. The stylus of the telegraph became too heavy; the cable can transmit far more signals than the stylus can print; a single cable could transmit thirty simultaneous calls. In the electron tube the transit-time of electrons between cathode and anode limits eligible frequencies exceptionally well; the smallest electron tube is the one that can best rise in frequency, but this same tube then has very low power, since its small dimensions do not enable it to shed enough heat without reaching a temperature that compromises its operation. It is possible that one of the reasons for the trend towards size-reduction that has been going on since 1946 lies in the discovery of this imperative in information technology: construct technical individuals and especially elements that are very small in size, because they are more perfect and have better information efficiency.

III.—THE LIMITS OF THE CONCEPT OF INFORMATION TECHNOLOGY IN ACCOUNTING FOR THE RELATION BETWEEN MAN AND THE TECHNICAL OBJECT. THE MARGIN OF INDETERMINACY IN TECHNICAL INDIVIDUALS. AUTOMATISM

Nevertheless, a philosophy of technology cannot be exclusively founded on unconditional research into form and the efficiency of form in the transmission of information. Both kinds of efficiency, which seem to diverge, and which do in fact diverge originally, nevertheless meet further on: when the quantity of energy that is used as a carrier of information tends towards a very low level, a new type of efficiency loss appears: this loss is due to the basic energy discontinuity. The energy that serves as information carrier is in fact modulated in two ways: artificially, by the signal to be transmitted; essentially, in accordance with its

physical nature, by the basic discontinuity. This basic discontinuity appears when the average level of energy is of an order of magnitude slightly higher than the instantaneous variations resulting from the basic energy discontinuity; the artificial modulation therefore merges with this essential modulation, with white noise or background fog superimposed on the transmission; here there is no harmonic distortion, since the modulation is independent of that of the signal and is not a deformation or loss of the signal. Now, to diminish the background noise the bandwidth can be decreased, and this also decreases the information efficiency of the proposed channel. A compromise should be adopted which retains information efficiency that is adequate for practical purposes and an energy efficiency that is high enough to keep the background noise at a level that does not disturb signal-reception.

This antagonism, which is hardly ever referred to in recent works devoted to philosophy of information technology, nevertheless marks the non-univocal nature of the concept of information. Information is, in a sense, something that can be infinitely varied, something that, in order to be transmitted with the least possible loss, requires a sacrifice of energy efficiency so as not to shrink the range of possibilities in any way. The most reliable amplifier is one whose energy efficiency is very uniform and independent of the frequency scale; it favors none, imposes no resonance, no stereotyping, and no pre-established regularity on the open series of varied signals that it must transmit. But, in another sense, information is something whose transmission depends on its being above the level of purely chance phenomena, such as the white noise of thermal agitation; so, information has regularity, localization, a defined domain, and a specific stereotyping that distinguishes it from pure chance. When the level of background noise is high, the information signal can still be saved if it observes a certain law, that is to say, if it offers some predictability in the course of the temporal series of successive states that constitute it. For example, in television, the fact that the frequency of the time-bases is defined well in advance makes it possible to extract timing pips from the equally-important background noise by blocking the synchronization-devices for nine-tenths of the time and by unblocking them for just a brief instant (a millionth of a second, for example) when the timing-pip has to occur because of the already specified law of recurrence (this being the phase-comparison device used for long-distance receptions). Now, we really have to treat the reception of synchronization signals as information. But this information is more easily extracted from background noise because the disruptive action of the background noise can be limited to a very small fraction of the total time and, thereby, all manifestations of background noise that fall outside of this time can be rejected as nonsignificant. Of course, this device is not effective against a spurious signal which in turn also obeying a law of recurrence with a time very close to the time scheduled for signal reception. So, there are two aspects of information, which are distinguished technically by the opposite conditions they need for transmission. Information is, in a sense, that which brings about a series of unpredictable states, that are new and are not part of any series that is definable in advance; so, it requires that the information channel be absolutely available for

all aspects of the modulation it dispatches; the information channel should not have any predetermined form of its own, should not be selective. A perfectly reliable amplifier should be able to transmit all frequencies and all amplitudes. In this sense, information has some characteristics in common with purely contingent phenomena, that follow no rule, such as the movements of molecular thermal agitation, radioactive emission, and discontinuous electronic emission in the thermo-electronic or photoelectric effect. This is why a very reliable amplifier[7] produces a more pronounced background noise than a low-bandwidth amplifier, because it amplifies uniformly the white noise produced by various causes in its various circuits (in resistances by thermal effect, in tubes by the discontinuity of electronic emission). However, noise has no meaning, whereas information has meaning. In an opposite sense, information is distinguished from noise because a code, a relative standardization, can be assigned to information; in every case where the noise cannot be directly lowered below a certain level, a reduction of the margin of indeterminacy and unpredictability in the information signals takes place; this is the case, as indicated above, in the reception of synchronization signals by a phase comparator. What is reduced here is the margin of temporal indeterminacy: it is assumed that the signal will occur at some point in a temporal interval equal to a minimal fraction completely determined by its phase in the time of the recurrent phenomenon. The device can be much more finely tuned when the stability of the transmitter and the stability of the receiver are greater. The greater the predictability of the signal, the more easily this signal can be distinguished from the phenomenon of chance which is the background noise. The same goes for the reduction of the frequency band: when a circuit can no longer transmit speech because of a too loud background noise, a single-frequency signal can be used, as is the case in the Morse alphabet; at the reception, a filter tuned to this single emission frequency lets pass only those sounds whose frequency is within this narrow band; so, a low level of background noise gets through, the lowness of its level decreasing according to the narrowness of the band received, which means sharper resonance.

This opposition is a technical contradiction that poses a problem for philosophical thinking: information is like a chance event and is yet distinct from it. By excluding all novelty, an absolute stereotypy also excludes information. However, the distinction between information and noise is based on a character of the reduction of limits of indeterminacy. If the time bases were truly foolproof like Leibniz's monads, it would be possible to reduce at will the time sensitivity of the synchronizing oscillator: the informational role of the synchronizing pulse totally disappears, because there would be nothing to synchronize: the synchronizing signal would no longer have an unpredictable character in relation to the synchronizing oscillator; if the informational nature of the signal is to remain, a certain margin of indeterminacy must remain. Predictability is a base receiving this additional precision, and in a very large number of cases distinguishing it in advance from pure chance, partially prefiguring it. Information is thus mid-way between pure chance and absolute regularity. One could say that form, conceived as pure regularity, spatial as well as temporal, is not so much information as a

[7] A large bande passante (Simondon's bilingual note.)

condition of information; it is a host for information, the *a priori* that receives information. Form has a selective function. But information is not form, nor is it a combination of forms; it is the variability of forms, the contribution of variation to a form. It is the unpredictability of variation in form, not the sheer unpredictability of all variation. We would therefore have to distinguish between three terms: pure chance, form, and information.

Now, up to our own day, the new phase of the philosophy of technology following the contemporary phase of thermodynamics and energetics has not adequately distinguished between *form* and *information*. In fact, there is a major gap between the living and the machine, and consequently between man and machine, which derives from the fact that the living are in need of information, whereas the machine primarily uses forms and is basically constituted with forms. Philosophical thinking cannot adequately grasp the meaning of the coupling of machine and man unless it succeeds in elucidating the true relationship between form and information. The living transforms information to forms, the *a posteriori* to the *a priori*; but the *a priori* is always oriented toward the reception of information to interpret. The machine, on the contrary, was constructed according to a number of schemes, and it functions in a specific manner; its technicality and its functional concretization at the level of the element are determinations of forms.

The human individual then seems to have to convert to information the forms set down in machines; the operation of machines does not generate information, because it is only an assemblage and a modification of forms; the functioning of a machine has no meaning, and cannot give rise to real information-signals for another machine; the mediation of the living is needed to interpret functioning in terms of information and to reconvert it into forms for another machine. Man understands machines; he has a function to play between machines rather than beyond them, so that there can be a true technical ensemble. It is man who discovers meanings: meaning is the sense an event derives from its relation to forms that already exist; meaning is what gives an event information value.

This function is complementary to the function of invention in technical individuals. Man, the interpreter of machines, is also the one who, using his schemes, established strict forms that allow a machine to function. The machine is a human gesture that is set down, fixed, stereotyped, and with restarting power. The rocker with two fixed states* was conceived and constructed once upon a time; man imagined its functioning on a limited number of times, and now the rocker endlessly performs its equilibrium-reversing operation. It perpetuates in a specific way the human transaction that formed it; its construction involved a transition from mental functioning to physical functioning. There is a real and profound dynamic analogy between the process by which man conceived the rocker and the physical functional process of the constructed rocker. Between the human inventor and the machine that functions there is a more critical isodynamic relation than the relation called isomorphism which psychologists of Form had dreamt up in order to explain perception. The analogical relationship between the machine and man is not at the same level as bodily functioning; the machine does not feed itself, does not perceive, does not take a rest, so cybernetic literature is

wrong when it uses what only appears to be an analogy. Indeed, the true analogical relationship is the analogy between the man's mental functioning and the machine's physical. Both these functions are parallel, not in everyday life, but in invention. To invent is to make one's thought work as a machine works, neither according to causality, which is too fragmentary, nor according to purpose, which is too unitary, but according to the dynamism of lived functioning, understood as a product, and understood also in its genesis. The machine is a being that works. Its mechanisms give material expression to a coherent dynamism that once existed in thought, and that was thought. The dynamism of thought, at the time of invention, was converted into functioning forms. Conversely, the machine, in functioning, undergoes or produces a certain number of variations around the basic rhythms of its functioning, as they result from its set forms. These are significant variations, and they are significant in relation to the archetype of its functioning, the archetype in the mind during the process of invention. The machine would have to be invented or reinvented to make it possible for the functional variations of the machine to become information. In itself the noise of an engine has no value as information; it acquires this value from a variation in its rhythms, a variation in its frequency or tone, an alteration in the transients that express a change in functioning relative to the functioning determined in its invention. When the correlation between machines is purely causal, there is no need for the human being to intervene as interpreter between machines. But the role of man as interpreter is necessary when machines have a regulation; a machine that has a regulation is in effect a machine that conceals some margin of indeterminacy in its functioning; it may, for example, go fast or slow. From then on, variations in speed are significant and may reflect what is happening outside the machine, in the technical ensemble. The more automated the machines, the greater the reduction of possible variations in speed; hence they can go unnoticed: but in fact what happens here is what happens to a very stable oscillator that is synchronized by another even more stable oscillator: the oscillator can continue to receive information as long as it is not strictly stable, and even though the margin of indeterminacy of its operation is reduced, the synchronization still has a meaning within this margin of indeterminacy. The pulse of synchronization has meaning when it acts as a very slight variation on the temporal form of the recurrence of states of functioning. Likewise, the reduction of operational indeterminacy in no way isolates the machines from one another; it makes the significant variation with informational value more precise, more rigorous, and more detailed. But these variations always have meaning in relation to schemes essential to the invention of the machine.

The notion of a perfect automaton is a notion obtained by going to the limit, and it conceals something contradictory: *the automaton would be such a perfect machine that its margin of functional indeterminacy would be zero, but it could nevertheless receive, interpret, or transmit information*. Now, if the margin of indeterminacy of the functioning is zero, no variation is possible; the functioning is repeated indefinitely, and consequently this iteration has no meaning. Information is maintained in the course of automation because the sharpness of the signals increases with the reduction of the margin of indeterminacy, and this makes the

signals retain meaningful value even if this margin of indeterminacy becomes extremely narrow. For example, if oscillators are stable to about a one thousandth in frequency variation, synchronization pulses whose possible phase-rotation would vary at about ten percent over the time, or that would have a steep front and variable duration, would have only a low informational value for synchronization. To synchronize oscillators that are already very stable, perfectly cut short pulses are used whose phase-angle is strictly constant. The information is all the more meaningful or, rather, a signal has all the more information-value the more it intervenes in accord with an autonomous form of the individual that receives it; so, when the synchronizing oscillator's own frequency is far from pulse frequency synchronization, no synchronization occurs; as opposed to this, synchronization occurs for signals that become weaker as the autonomous frequency and the frequency of synchronizing pulses approach one another. However, this relationship must be precisely interpreted: so that recurrent pulses can synchronize an oscillator, these pulses must arrive at a critical period in the operation: the moment that immediately precedes the reversal of equilibrium, in other words just before the beginning of a phase; the synchronizing pulse arrives as a very slight supplementary quantity of energy that accelerates the transition to the next phase, when this transition has not yet been perfectly completed; the pulse *triggers*. That is why the greatest precision and highest sensitivity in synchronization are obtained when the autonomous frequency would be just slightly lower than the synchronizing frequency. With regard to this form of recurrence, the pulses with a very slight edge take on meaning, convey information. The moment the equilibrium of the oscillator is about to reverse is the moment when a metastable state is created, with accumulation of energy.

The existence of critical phases explains the difficulty in synchronizing a functioning offering no sudden reversal of states: a sinusoidal oscillator is less easily synchronized than a relaxation oscillator; the margin of indeterminacy is in fact less important in the functioning of a sinusoidal oscillator; its functioning can be modified at any time during its period; on the other hand, in a relaxation oscillator, the indeterminacy is accumulated at the end of every cycle rather than distributed over the entire duration of the cycle; when the equilibrium is reversed, the relaxant (*relaxateur**) is no longer sensitive to the pulse that arrives; but when it is at the tipping point, it is extremely sensitive; contrary to this, the sinusoidal oscillator is sensitive throughout the phase, but moderately.

So, the existence of a margin of indeterminacy in machines must be understood as the existence of a number of critical phases in functioning; the machine that can receive information is the one that temporally localizes its indeterminacy at sensitive moments that are rich in possibilities. This structure is the structure of decision, but it is also the structure of relay. Machines that can receive information are those that localize their indeterminacy.

This notion of localizing operational decisions is not absent from the works of cyberneticists. But what is lacking in this study is the notion of the reversibility of information reception and of information transmission. If a machine functions with critical phases such as those of a relaxation oscillator, it can transmit information just as well as it receives it; hence, a relaxation oscillator because of its

discontinuous operation transmits pulses that can be used to synchronize another relaxant. If a coupling is made between two relaxants, the two oscillators become synchronized in such a way that it is impossible to specify which one is synchronizing and which is synchronized; in fact, they are mutually synchronized, and the ensemble functions as a single oscillator, with a time that is slightly different from the specific times of each of the oscillators.

It may seem too easy to oppose open and closed machines in the sense Bergson gives to these two adjectives. Yet, this difference is real; the existence of regulation in a machine leaves the machine open to the extent that it localizes critical times and critical points, that is to say those from which the energy channels of the machine can be modified, changing characteristics. The individualization of the machine goes hand in hand with this separation of forms and of critical elements; a machine can be in connection with the outside to the extent that it has critical elements; now, the existence of these critical points in the machine justifies the presence of man: the running speed of the machine can be modified by information coming from the outside. Hence a calculator is not only, as is generally said, a set of rockers. It is true that the calculator has a large number of specific forms, those for the operation of the series of rockers, representing a series of added transactions. But if the machine consisted of that only, it would be unusable, because it would be unable to receive information. In fact, it also contains what might be called the system of decision flow charts; before the machine can be used *it must be programmed*. With the multi-vibrator that provides the pulses and the series of rockers that do the adding, it still would not be a calculator. There has to be a degree of indeterminacy to make calculation possible: the machine includes a set of selectors and of commutations that are controlled by programming. Even in the simplest case, that of a scale composed of rockers and counting pulses, such as those used in the wake of Geiger-Müller tube-counters, there is a degree of indeterminacy in the operation; the Geiger tube under voltage is in the same state as a relaxation oscillator at the moment when it is about to begin a new phase, or as a multi-vibrator at the moment when it is about to switch by itself. The only difference is that this metastable state (corresponding to the voltage-plateau of a Geiger-Müller tube) continues in a sustainable manner in the tube up to the point where supplementary energy triggers ionization, whereas in the relaxant or the multi-vibrator this state is transient because of the continuation of the activity of resistance circuits and capacities outside the electronic tube or the thyratron.

This margin of indeterminacy is found again in all devices, of different types, that can transmit information. A continuous relay such as a thermoelectric or crystalline triode can transmit information because the existence of a potential energy defined across the supply circuit is not sufficient to determine the quantity of effective and current energy sent to the output circuit: this relationship of open possibility in the updating of energy is closed only by the additional condition which is the arrival of information on the controller. A continuous relay can be defined as a transducer, that is, as an adjustable resistance interposed between a potential energy and the site of the updating of that energy: this resistance is adjustable by information exterior to the potential energy and to the energy current. Again the

term "adjustable resistance" is too vague and inadequate; if, in fact, this resistance were a true resistance, it would be part of the domain for updating the potential energy. Now, in a perfect transducer no energy is updated; and moreover, none is put in reserve: the transducer is neither part of the domain of potential energy nor of the domain of the energy current: it is in truth the mediator between these two domains, but it is neither a domain of energy-accumulation nor a domain of updating: it is the margin of indeterminacy between these two domains, that which leads potential energy to its updating. Information intervenes in the course of this transition from potential to current; information is a requirement for updating.

Now, this notion of transduction can be generalized. Presented in its pure state in transducers of different sorts, it exists as a regulative function in all machines that have a certain margin of indeterminacy localized in their operation. The human being and living beings generally are essentially transducers. The elementary living being, the animal, is itself a transducer when it puts chemical energies in reserve, and then updates them in the course of different living operations. Bergson very clearly highlighted this function of the living which accumulates potential energies and suddenly dispenses them; but here Bergson was concerned to show a function of temporal condensation that would be constitutive of life; now, the relationship between the slowness of the accumulation and the instantaneous abruptness of the updating does not always exist; the living can slowly realize its potential energy, as in the case of thermal control or muscle tone; what is essential is not the difference between the temporal rates of potentiation and updating, but the fact that the living intervenes as transducer between this potential energy and the energy current; the living is *that which modulates*, that in which there is modulation, neither a reservoir of energy nor an effector. Nor does it suffice to say: the living assimilates; assimilation is a source of free potential energy that is updatable in the functions of transduction.

The relation of man to machines occurs at the level of functions of transduction. It is in fact very easy to build machines that ensure an accumulation of energy far superior to what man can accumulate in his body; it is equally possible to use artificial systems that are far superior effectors to those in the human body. But it is very difficult to construct transducers comparable to the living. In fact, the living [being] is not exactly a transducer like those that machines can include; the living is that and something more; mechanical transducers are systems that have a margin of indeterminacy; information is what provides determination. But this information must be supplied to the transducer; the transducer does not invent it; the information is supplied to the transducer by a mechanism similar to perception in the living, for example, by a signal from the way in which the effector functions (the gauge on the output shaft in a heat engine). On the other hand, that which is living can provide itself with information, even in the absence of any perception, because it can modify the forms of problems to be solved; for the machine, there are no problems, but only data that modulate transducers; many transducers interacting according to switchable schemes, such as the Ashby homeostat, are not a problem-solving machine: in a relation of reciprocal causality, transducers are all *in the same time*; they affect one another in the present; for them there is no such thing as a problem,

something tossed in front of them, something lying ahead to step across. To solve a problem is to be able to step over it, to be able to recast the forms that are the very data of the problem. The solution to real problems is a vital function that requires a recurrent mode of action which is impossible in a machine: the recurrence of the future on the present, of the virtual on the actual. For a machine there is no such thing as the real virtual; the machine cannot reform its forms in order to solve a problem. When the Ashby homeostat switches itself on in the course of operation (because one can attribute to this machine the power of acting on its own selectors), a jump in characteristics occurs that wipes out every earlier operation; at each moment the machine exists in the present, and the power to apparently change its forms is ineffective because nothing of the old forms remains; everything occurs as if there were a new machine; each function is momentary; when the machine changes forms as it switches it does not switch in order to find another form directed to the solution of the problem; there is no modification of forms directed by a hunch about the problem that needs to be solved; the virtual does not react to the actual because the virtual as virtual cannot play a role for the machine. It can only react to something positive in the given data, a fact of the present moment. The faculty the living being has to modify itself as a function of the virtual is the sense of time, something the machine does not have because it is not alive.

Technical ensembles are characterized by the fact that a relationship between technical objects is established in them at the margin of the operational indeterminacy of each technical object. This relationship between technical objects, to the extent that it correlates indeterminacies, is problematic in kind, and for that reason cannot be assumed by the objects themselves; it cannot be the object or the result of a calculation: it has to be conceived of, and posed as a problem by a living being and for a living being. What we have called a coupling between man and machine can be expressed by saying that man is responsible for machines. This is not the responsibility of the producer as source of the product, but of a third person, the witness of a difficulty that he alone can solve because he alone has the power to think; man is the witness of machines and he represents each in relation to the others; machines can neither think nor live their mutual relationship; they can only act one upon the other in the present according to schemes of causality. As the witness of machines man is responsible for their relationship; the individual machine represents man, but man represents the ensemble of machines, because there is no such thing as a machine for all machines, whereas it is possible to think about all machines.

A technological attitude would be a good name for the attitude that makes a man concerned not only with the use of a technical being but also with the correlation of technical beings with each other. The present-day opposition between culture and technology is a result of the fact that the technical object and the machine are thought of as identical. Culture does not understand the machine; culture is inadequate to technical reality because it thinks of the machine as a closed world and thinks of mechanical functioning as an repetitive stereotypy. The opposition between technology and culture will endure until culture discovers that each machine is not an absolute unit but merely an individualized technical

reality that is open in two ways: the first, through its relationship with elements, the second, through inter-individual relationships in the technical ensemble. The role that culture has assigned to man with the machine is at odds with technical reality; it assumes that the machine has been substantialized, materialized, and is, as a consequence, devalued; as a matter of fact, the machine is less consistent and less substantial than culture assumes; it does not relate to man as a unit; it relates to him in the free plurality of its elements, or in the open series of its possible relationships with other machines within the technical ensemble. Culture is unfair to the machine not only in its judgments or its prejudices but even in knowledge itself: the cognitive bias of culture to the machine is substantializing; the machine is enclosed in this reductive vision which deems it complete in itself and perfect, and this makes it coincide with its current state, with its material determinations. A similar attitude to an object of art would be to reduce a picture to an expanse of dry, cracked paint on a stretched canvas. The same attitude to the human being would consist in reducing the subject to a fixed set of vices and virtues, or to character traits[8].

To reduce art to art objects, to reduce humanity to a list of individuals who are no more than representations of character traits, is to act like people who reduce technical reality to a collection of machines: now, in the first two cases this attitude is thought of as crude; in the following case it is acceptable because it conforms to the values of culture, even though it involves the same destructive reduction of the first two cases. But it operates by taking an implicit judgment from knowledge itself. It uses an already distorted idea of the machine, as distorted as the idea of the foreigner in group stereotyping.

Now, the foreigner as foreigner cannot become the object of cultured thinking; that object must be the human being. The stereotype of the foreigner cannot be transformed into an accurate and adequate depiction unless the connection between the being making the judgment and the being who is the foreigner is diversified and multiplied so as to arrive at a multiform mobility that gives it consistency, a defined power of reality. A stereotype is a two-dimensional depiction, like an image without depth or plasticity. For the stereotype to become a representation, it is necessary that experiences of relationship with the foreigner should be many and varied. The foreigner, no longer a foreigner, becomes the other, when there are foreigner beings who are recognized by the subject who judges but also by other foreigners; the stereotype falls apart when the relationship between the subject and the foreigner is properly known by other beings, when both subject and foreigner are no longer enclosed in a mutual, asymmetrical, immutable situation. Likewise, stereotypes relating to the machine can be modified only if the relationship between man and machine (an asymmetrical relationship as long as it is experienced in an exclusive manner) can be seen objectively while being exercised between terms independent of the subject, between technical objects. To incorporate representations of technical contents into culture, there must be an objectification of the technical relationship for man.

The predominant and exclusive attention given to a machine can no more lead to the discovery of technicity than the relationship with a unique type of

[8] This reductive attitude can also apply to a whole region (regionalism).

foreigners can lead to a penetration of the interiority of their way of life and to knowing it as culture. Nor is frequent contact with many machines enough, any more than frequent contact with many foreigners; these experiences only lead to xenophobia or xenophilia, which are opposite attitudes but equally vehement. To consider a foreigner through culture, one must have witnessed from outside of oneself, objectively, the relationship that makes it possible for two beings to be foreign to each other. Likewise, if a single technic cannot convey cultural content, neither can a polytechnic do so; it only engenders a trend towards technocracy or a rejection of technics as a whole.

IV. -- PHILOSOPHICAL THINKING MUST INTEGRATE TECHNICAL REALITY WITH UNIVERSAL CULTURE BY FOUNDING A TECHNOLOGY

The dawn of conditions permitting man to see in an objective way the working of the technical relationship is the primary condition for incorporating the knowledge of technical reality into culture and the values implied in culture by its existence. Now, these conditions are realized in technical ensembles using machines that have a sufficient degree of indeterminacy. The fact that he has to intervene as mediator in this relation between machines gives man the independence by which he can acquire the cultural vision of technical realities. Engagement in an asymmetrical relation with a single machine cannot provide the distance necessary for the dawn of what we could call technical wisdom. Only the situation involving a concrete link with and responsibility to machines, as well as freedom concerning each individually, can provide the serenity for this technical awareness. Just as the constitution of literary culture needed sages who lived in a retreat that allowed them dispassionately and with depth of judgment to contemplate inter-human relations, while maintaining an intense presence among human beings, so there can be no technical culture without the development of a certain kind of wisdom, which we will call technical wisdom, among men who feel their responsibility towards technical realities but remain disengaged from an immediate and exclusive relation with a particular technical object. It is very difficult for a worker[9] to arrive at knowledge of technicity through the characters and terms of his daily work on a machine. It is also difficult for a man who owns machines and sees them as productive capital to know their essential technicity. The mediator of the relation between machines is the only one who can discover this particular form of wisdom. Now, a function of this sort has no established social position as yet; it would be the function of the engineer in an organization if he were not preoccupied with immediate productivity and governed by a purpose external to engine speed, productivity. The function we are trying to outline would be that of a psychologist of machines, or of a sociologist of machines, what we might call a mechanologist.

There is a sketch of this role in the intention with which Norbert Wiener founded cybernetics, the science of control and communication in the living being and in the machine. The meaning of cybernetics has been poorly understood,

[9] It might be better to use the neutral term operator.

because this eminently new endeavor has been belittled by being judged in the light of old notions or trends. In France cybernetic research, which assumes a unity in the theory of information and schemes of control and self-regulation, split into two divergent branches, one branch being the theory of information with Louis de Broglie and the team that publishes its work in the *Revue d'Optique* and the other branch being researches into automatism, with engineers such as Albert Ducrocq, representing technicist and technocratic trends. Now, liaison between these two trends would make possible the discovery of values involved in technical realities and their incorporation into culture. The theory of Information is in fact scientific; it uses modes of operation related to those used by the theory of heat. As opposed to this, the technicism of Ducrocq examines the function of automatic machines for an example of a number of functions that make possible the interpretation of other kinds of reality by analogy with automatism. The theory of self-regulating mechanisms makes it possible in particular to outline a hypothesis explaining the origins of life. These are either principal mental operations or else they are just certain nervous functions which are thus explained by analogy. In fact, similar analogies, even if they are not arbitrary, merely indicate that there are operations common to the living and to machines. They leave open the problem of the very nature of those operations: this technicism is more a phenomenology than an in-depth inquiry into the nature of the schemes and conditions that govern their implementation.

Of course, one can refuse to accept the way in which Norbert Wiener characterizes information and the essential premise of his work, which is to say that information is opposed to background noise in the same way that negative entropy is opposed to the entropy defined by thermodynamics. However, if the opposition between divergent determinism and convergent determinism does not reflect the entirety of technical reality and its connection with life, this opposition contains within itself a method for discovering and defining a set of values involved in technical operations and in the concepts used to consider them. But it is possible to add an extension to Norbert Wiener's reflection. At the end of his work, the author asks himself how the concepts he has defined could be used for the organization of society. Norbert Wiener states that large groups tend to have less information than small groups and he explains this fact by the tendency of less "homeostatic" human elements to have leadership roles in large groups; on the other hand, according to Norbert Wiener, the amount of information contained in a group would be proportional to the degree of perfection of the homeostasis of the group. The fundamental moral and political problem would then be to ask how individuals who represent homeostatic forces can be put in place as leaders of groups. But Norbert Wiener goes on to say that none of the individuals who understand the value of homeostasis and who also understand what information happens to be is able to take power; and, when they come face to face with men who preside over collective destinies, cyberneticists as a whole act like the mice that want to bell the neck of the cat (*Cybernetics*, p.189). The forays the author made among trade union leaders filled him with a bitterness that calls to mind Plato describing his disappointments in his *Seventh Letter*. Still, between the understanding of technics and the force that guides human groups, we may be

able to discover a very different mediation from what Norbert Wiener contemplates. For it is difficult to make philosophers kings and kings philosophers. It often happens that when philosophers become kings they are no longer philosophers. True mediation between technics and power cannot be individual. It cannot be achieved unless the intermediary is culture. For there is something that allows man to govern: the culture he has received; this culture is what gives him meanings and values; culture governs man, even though that man governs other men and machines. Now, culture is developed by the great mass of those who are governed; to the extent that, strictly speaking, the power exercised by one man does not come from him but is, rather, crystallized and materialized in him; it comes from humans who are governed and it returns to them. Here there is a kind of recurrence.

At the time when technical development was slight, the development of culture by governed humans was enough to make the government think about group-related problems as a whole: the recurrence of causality and information was complete and thorough, because it went from human group to human group through the ruler. But this is no longer the case: fundamentally, culture is always exclusively human; it is formed by humans as a group; now, having passed through the ruler, it returns and is applied to the human group on the one hand and to machines on the other: machines are ruled by a culture that they had no part in developing and from which they are absent: this culture is inappropriate to them; it does not represent them. If reality escapes the human ruler, it is because fundamentally it is exclusively human. Culture is regulatory and culture forms the link of circular causality between the ruler and the governed: its point of departure and its end-point are the governed. The lack of social homeostasis comes from the fact that an aspect of governed reality is not represented in the regulatory relationship which is culture.

The task of the technologist, therefore, is to be the representative of technical beings to people who develop culture: to writers and artists and, generally, to those called cynosures in social psychology. This does not mean that society should be mechanized by the integration into culture of an adequate representation of technical realities. There is no reason to consider society as the domain of an absolute homeostasis. Norbert Wiener seems to allow for an unnecessary postulate of values when he says that a good homeostatic regulation is a final end for societies, and that it is an ideal that should animate very act of state. In fact, just as the living [being] depends on homeostasis to develop and evolve instead of remaining perpetually in the same state, so in the act of state there is a force of absolute futurity that depends on, and surpasses, and makes use of homeostasis. The integration into culture of a representation of technical realities by an elevation and an expansion of the technical domain should put problems of finality in their proper place as technical problems of finality rather than the ethical, and sometimes religious, problems they are mistakenly thought to be. The incompleteness of technics regards problems of finality as sacred and enslaves the human to a respect for ends which he imagines to be absolutes.

For this reason, not only should technological objects be known on their current level, but, like the religious mode and the aesthetic mode, the technicity of

those objects [should also be known] as one mode of man’s relationship to the world. Taken on its own, technicity tends to become dominant and to provide an answer to every problem, as it does today with the cybernetics system. In fact, to be properly known according to its essence, and to be rightly integrated into culture, technicity should be known in relation to other modes of being in the world of man. No inductive study, starting from the plurality of technical objects, can discover the essence of technicity: therefore an attempt should be made to use a philosophic method and make a direct examination of technicity as a genetic method.

On the Mode of Existence of Technical of Technical Objects
by
Gilbert Simondon

❖

THIRD PART

THE ESSENCE OF TECHNICITY

❖

Chapter I

THE GENESIS OF TECHNICITY

❖

I – THE NOTION OF PHASE APPLIED TO BECOMING: TECHNICITY AS PHASE

This study postulates that technicity is one of the two fundamental phases of the mode of existence of the ensemble constituted by man and the world. By phase, we do not mean one temporal moment replaced by another, but an aspect that results from a division of being and that is opposed to another aspect. This sense of the word phase is inspired by the notion of phase relation in physics; one cannot conceive of a phase except in relation to another or to several other phases; in a system of phases there is a relation of equilibrium and of reciprocal tensions; the present system of all the phases taken together is the complete reality, not each phase itself since a phase is a phase only in relation to others, and it is distinguished from them in a manner that is totally independent of notions of genus and species. Finally, the existence of a plurality of phases defines the reality of a neutral centre of equilibrium in relation to which the phase-shift exists. This schema is very different from the dialectical schema, because it implies neither necessary succession nor the intervention

of negativity as engine of progress; moreover, in the schema of phases, the opposition exists only in the particular case of a biphase structure.

The adoption of such a schema founded on the notion of phase is destined to put in play a principle according to which the temporal development of a living reality proceeds by division from an initial active centre and then by regrouping after the advance of each separate reality resulting from the division. Each separate reality is a symbol of the other, just as one phase is a symbol of the other or of others; no phase, as phase, is in equilibrium in relation to itself, nor does it have complete truth or reality: every phase is partial, abstract, and unbalanced; only the system of phases is in equilibrium at its neutral point; its truth and its reality are this neutral point, the procession and conversion in relation to this neutral point.

We suppose that technicity results from a phase-shift of a central, original, and unique mode of being in the world, the magical mode; the phase that balances technicity is the religious mode of being. Aesthetic thinking emerges at the neutral point between technics and religion, at the moment of the division of primitive magical unity: this is not a phase but, rather, a permanent reminder of the rupture of the unity of the magical mode of being and a search for a future unity.

Each phase in turn divides into a theoretical mode and a practical mode; there is thus a practical mode of technics and a practical mode of religion, as well as a theoretical mode of technics and a theoretical mode of religion.

Just as the distance between technics and religion generates aesthetic thinking, so the distance between the two theoretical modes (the technical and the religious) generates scientific knowledge as mediation between technics and religion. The distance between the practical technical mode and the practical religious mode generates ethical thinking. Aesthetic thinking is therefore a mediation between technics and religion, that is more primitive than science and ethics, for the birth of science and ethics requires a prior division within technics and religion between the theoretical mode and the practical mode. From this results the fact that aesthetic thinking is truly situated at the neutral point, extending the existence of magic, whereas science on the one hand and ethics on the other are in conflict in relation to the neutral point, since there is the same distance between them as there is between the theoretical mode and the practical mode in technics and in religion. If science and ethics could have converged and united, they would have coincided in the neutral axis of this genetic system, thereby providing a second analogue of magical unity, over and above the incomplete aesthetic thinking that is its first analogue, incomplete because it allows the phase-shift between technics and religion to subsist. This second analogue would be complete; it would replace at once magic and aesthetics; but perhaps it is only a simple tendency playing a normative role, since nothing proves that the distance between the theoretical mode and the practical mode can be completely bridged.

In order to indicate the true nature of technical objects, it is therefore necessary to resort to a study of the entire genesis of the relations between man and the world; the technicity of objects would then seem to be one of the two phases of the relation of man to the world engendered by the division of primitive magical unity. Should technicity then be

considered as a simple moment in a genesis? – Yes, in a certain sense: there is certainly something transitory in technicity, which itself becomes divided into theory and practice and participates in the subsequent genesis of theoretical thinking and of practical thinking. But, in another sense, there is something definitive in the opposition of technicity to religiosity, because man's primitive way of being in the world (magic) can be thought to provide inexhaustibly an indefinite number of successive contributions that can be divided into a technical phase and a religious phase; in this manner, although effectively there is succession in genesis, the successive stages of the different geneses are simultaneous within culture, and there are relations and interactions not only between simultaneous phases but also between successive stages; hence, technics can encounter not only religion and aesthetic thinking but also science and ethics. Now, if one adopts the genetic postulate, one notices that a science or an ethics can never encounter a religion or a technics on a truly common ground, since the modes of thinking that are different in degree (for example a science and a technique) and that exist at the same time do not constitute a single genetic lineage, do not issue from the same surge of the primitive magical universe. True and balanced relations only exist between phases of the same level (for example a technical ensemble and a religion) or between successive degrees of genesis that are part of the same lineage (for example between the stage of technics and of religions in the seventeenth century and the contemporary stage of science and of ethics). True relations exist only in a genetic ensemble balanced around a neutral point, envisaged in its totality.

This is precisely the goal to be reached: reflexive thinking has a mission to redress and refine the successive waves of genesis by which the primitive unity of the relation of man to

the world becomes divided and comes to sustain science and ethics through technics and religion, between which aesthetic thinking develops. In these successive divisions, primitive unity would be lost if science and ethics were not able to come together at the end of the genesis; philosophical thinking is inserted between theoretical thinking and practical thinking, in the extension of aesthetic thinking and of the original magical unity.

Now, to make possible the unity of scientific knowledge and of ethics in philosophical thinking, the sources of science and of ethics have to be of the same degree, contemporaneous one with the other, and must have arrived at the same point of genetic development. The genesis of technics and of religion conditions that of science and of ethics. Philosophy is its own condition, for as soon as reflexive thinking begins, it has the power to perfect whichever of the geneses that has not been entirely achieved, by becoming aware of the sense of the genetic process itself. So, to be able to pose the philosophical problem of the relations between knowledge and ethics in a profound manner, it would be necessary first of all to complete the genesis of technics and the genesis of religious thinking, or at the very least (for this task would be infinite) to know the real meaning of these two geneses.

II. – THE PHASE-SHIFT OF PRIMITIVE MAGICAL UNITY

In order to understand the true relation of technics to other functions of human thinking, one must start with the primitive magical unity of the relations of man and world; through this examination it is possible to understand why philosophical thinking should

complete the integration of technical reality into culture, which is only possible by freeing the sense of the genesis of technics by the founding of a technology; so, the disparity between technics and religion subsides, harmful as it is to the intended reflexive synthesis of knowledge and ethics. Philosophy must found technology, which is the ecumenism of technics, because if ethics and the sciences are to meet up in reflection, a unity of technics and a unity of religious thinking needs to precede the division of each of these forms of thinking into a theoretical mode and a practical mode.

The genesis of a particular phase can be described in itself; but it cannot be really known in its sense and, consequently, understood in its postulation of unity, unless it is repositioned in the totality of its genesis, as a phase in relation to other phases. This is why in trying to understand technicity it is not enough to start with constituted technical objects; objects emerge at a certain moment, but technicity precedes and surpasses them; technical objects result from an objectification of technicity; they are produced by it, yet technicity is not exhausted in these objects and is not entirely contained in them.

If we eliminate the idea of a dialectical relation between successive stages of the relation between man and the world, what could be the engine of successive divisions during which technicity emerges? It is possible to appeal to the theory of Forms, and to generalize the relation that it establishes between figure and ground. Gestalt theory draws its basic principle from the hylemorphic schema of ancient philosophy, applied to modern considerations of physical morphogenesis: the structuring of a system would depend on spontaneous modifications tending toward a stable state of equilibrium. In reality, it seems

that a distinction should be made between a stable equilibrium and a metastable equilibrium. The emergence of the distinction between figure and ground results from a state of tension, from the incompatibility of the system in relation to itself, from what one could call the oversaturation of the system. But the structuring is not the discovery of the lowest level of equilibrium: stable equilibrium, in which all potential would be actualized, would correspond to the death of any possibility of further transformation; so, living systems, precisely those that manifest the greatest organizational spontaneity, are systems of metastable equilibrium. The discovery of a structure is at least a provisional resolution of incompatibilities, but it is not the destruction of potentials; the system continues to live and to evolve; it is not degraded by the emergence of structure; it remains tense and capable of being modified.

If one agrees to accept this corrective and to replace the notion of stability with that of metastability, then it seems that the Theory of Forms may account for fundamental stages in the evolution of the relation between man and the world.

Primitive magical unity is the vital relational link between man and the world, defining a universe at once subjective and objective prior to any distinction between object and subject, and consequently also prior to any emergence of the separate object. The primitive mode of the relation of man to the world can be thought of as not only prior to the objectification of the world, but even to the segregation of objective unities in the field that will become the objective field. Man finds that he is bound to a universe that is experienced as a milieu. The emergence of the object can only happen through the isolation and

fragmentation of the mediation between man and the world; and according to the principle proposed, this objectification of a mediation must have as correlative, in relation to the primitive neutral centre, the subjectification of mediation. The mediation between man and the world becomes objectified as a technical object, in the same way as it is subjectified as a religious mediator; but this objectification and this subjectification, contrary and complementary, are preceded by a primary stage of the relation to the world, the magical stage, in which the mediation is still neither subjective nor objective, neither fragmented nor universalized, and is the simplest and most fundamental structuring of the milieu of a living being: the birth of a network of privileged points of exchange between the being and the milieu.

The magical universe is already structured, but according to a mode that is prior to the segregation of object and subject; this primitive mode of structuring is the one that distinguishes figure from ground by marking key-points in the universe. If the universe were deprived of every structure, the relation between the living being and its milieu could occur in a continuous time and a continuous space, without privileged moment or place. In fact, preceding the segregation of unities, a reticulation of space and time is established that highlights privileged places and moments, as if all of man's power to act and all the capacity of the world to influence man were concentrated in these places and in these moments. These places and these moments possess, concentrate, and express the forces contained in the ground reality that supports them. These sites and these moments are not separate realities; they draw their force from the ground that they dominate; but they localize and focalize the attitude of the living vis-à-vis its milieu.

According to this general genetic hypothesis, we suppose that the primitive mode of existence of man in the world corresponds to a primitive union, prior to any division, of subjectivity and objectivity. The primary structuring, corresponding to the emergence of a figure and a ground in this mode of existence, is what gives birth to the magical universe. The magical universe is structured according to the most primitive and most fecund of organizations: that of the reticulation of the world into privileged places and privileged moments. A privileged place, a place that has a power, is one which draws into itself all the force and efficacy of the domain it delimits; it summarizes and contains the force of a compact mass of reality; it summarizes and governs it, as an highland governs and dominates a lowland; the elevated peak is the lord of the mountain,[1] just as the most impenetrable part of the wood is where all its reality resides. The magical world is in this way made of a network of places and things that have a power and are bound to other things and other places that also have a power. Such a path, such an enclosure, such a *temenos* contains all the force of the land, and is the key-point of the reality and of the spontaneity of things, as well as of their accessibility.

In such a network of key-points, of high-places, there is a primitive indistinction regarding human reality and the reality of the objective world. These key-points are real and objective, but in them the human being is immediately united with the world, both to be influenced by it and to act upon it; they are places of contact and of mixed, mutual reality, places of exchange and of communication because they form a knot between both realities.

[1] Not metaphorically but really: the geological folding and the eruption that built the whole massif are oriented toward the peak. The promontory is the firmest part of the chain eroded by the sea.

Yet, magical thought is the first, because it corresponds to the simplest, most concrete, most immense, and most supple structuring: that of reticulation. In the totality constituted by man and the world there emerges as the primary structure a network of privileged sites that make possible the insertion of human effort, and through which exchanges between man and the world are carried out. Each singular site concentrates within itself the capacity to have control over a portion of the world that it specifically represents and whose reality it conveys in communication with man. These singular sites could be called *key-points* controlling the man-world relationship in a reversible way, for the world influences man just as man influences the world. The summits of mountains or certain narrow passes are in this way naturally magical, because they govern a region. The heart of the forest and the centre of a plain are not just geographical realities metaphorically or geometrically designated: they are realities that concentrate natural powers as they focalize human effort: they are figural structures in relation to the masse that supports them and that constitutes their ground.

In general, we look to superstition when we want to find an example of the schemas of magical thinking in the actual conditions of life. In fact, superstitions are faded vestiges of magical thinking and, in a search for its real essence, they can only be misleading. On the other hand, to understand the meaning of magical thinking, it is advisable to resort to high, noble and sacred forms of thought that require a clear and insightful effort. That, for example, is the affective, representative, and voluntary substratum that supports an ascent or an exploration. Perhaps the desire for conquest and the sense of competition underlie the

motivation that makes it possible to move from everyday existence to exceptional acts; but certainly when the desire for conquest is invoked, it is a matter of making an individual act legitimate for a community. In fact, in the individual being or in the group limited to those who perform the exceptional act, the thinking implemented is much more primitive and much more elaborate.

Ascent, exploration and, more generally, every pioneering act consists in adhering to the key-points that nature presents. Climbing a slope in order to go toward the summit is to make one's way toward the privileged place that commands the entire mountainous massif, not in order to dominate or to take possession of it, but to enter into a friendly relationship with it. Man and nature are not strictly speaking enemies before such accession to the key-point, but strangers to one other. Until it has been climbed, the summit is only a summit, a place higher than the others. The ascent gives it the character of a place that is more fully developed, elaborate, and non-abstract, a place where this exchange between the world and man occurs. The summit is the place from which the whole massif is seen in an absolute way, while views from all other places are relative and incomplete, making one wish for the summit point of view. An expedition or a navigation that makes it possible to reach a continent by an established route does not conquer anything; nevertheless, in magical thinking they are valid in that they make possible contact with the continent in a privileged place that is a key-point. The magical universe is made up of the network of places providing access to every domain of reality: it consists of thresholds, summits, boundaries, and crossing points that are connected to one another by their singularity and their exceptional nature.

This network of boundaries is not only spatial but also temporal; there are notable dates and privileged moments to begin one action or another. Besides, the very notion of beginning is magical, even if every particular value is denied on the date of the beginning; the beginning of an action that is to last and the first act of what should be a long series ought not to have in themselves a particular majesty and power of direction, if they were thought to be controlling the entire duration of the action and the whole sequence of efforts, propitious or otherwise; dates are privileged points of time that make possible an exchange between human intention and the spontaneous unfolding of events. These are the temporal structures by which man is inserted in natural becoming, just as the influence of natural time affects each human life, becoming destiny.

In civilized life today, a great many institutions concern magical thinking, but are hidden by utilitarian concepts that indirectly justify them; in particular, time off, festivals, and vacations compensate with their magical charge for the loss of magical power imposed by civilized urban life. Thus, vacation trips, that are thought to provide rest and diversion, are in fact a quest for key-points old or new; these points can be the big city for country people, or the countryside for city dwellers, but more generally they are not any particular site in the city or the countryside; it [-- the key point --] is the shore or the high mountain or even the border crossed on the way to a foreign land. Public holidays are related to privileged moments of time; occasionally, a conjunction of singular moments and singular sites is possible.

So, ordinary time and ordinary space serve as ground for these figures; dissociated from the ground, figures would lose their meaning; time off and celebrations are not a release from ordinary life by suspending ordinary life, but a search for privileged places and dates in relation to the continuous ground.

This figural structure is inherent in the world, rather than detached; it is the reticulation of the universe in privileged key-points at which exchanges happen between the living being and its milieu. Now, it is precisely this reticular structure that goes out of phase when there is a shift from the original magical unity to technics and to religion: figure and ground separate by becoming detached from the universe to which they adhered. The key points become objective, retaining only their functional mediatory characteristics, becoming instrumental, mobile, capable of efficiency in any place and at any time; as figure, the key-points, detached from the ground for which they were the key, become technical objects, transportable and abstracted from the milieu. At the same time, the key-points lose their mutual reticulation and their power of distant influence on the reality that surrounded them; as technical objects they have only one action upon contact, site by site, instant by instant. This rupture of the network of key-points frees the characteristics of the ground, and these in turn become detached from their own ground, narrowly qualitative and concrete, in order to hover over the whole universe, throughout space and throughout time, in the form of detached powers and forces above the world. While the key-points become objective in the form of concretized tools and instruments, the ground powers become subjective by becoming personified in the form of the divine and the sacred (Gods, heroes, priests).

The primitive reticulation of the magical world is thus the source of an objectification and a subjectification that are in conflict; at the moment of the rupture of the initial structuring, the fact that the figure becomes detached from the ground is expressed by another detachment: figure and ground themselves are freed from their concrete adherence to the universe and take contrasting pathways; the figure becomes fragmented, whereas the ground qualities and forces become universalized: this break-up and this universalizing are forms of becoming, the figure becoming an abstract figure, and grounds becoming a single abstract ground. This phase-shift of the mediation into figural characteristics and ground characteristics translates into the emergence of a distance between man and the world. The meditation itself, instead of being a simple structuring of the universe, takes on a certain density; it becomes objectified in technics and becomes subjectified in religion, making the first object appear in the technical object and the first subject appear in divinity, when previously there had been a single unity of the living and its milieu: objectivity and subjectivity emerge between the living and its milieu, between man and the world, at a moment when the world does not yet have a complete status as object nor man a complete status as subject. Moreover, it can be affirmed that objectivity is never completely coextensive with the world, and that subjectivity is never completely coextensive with man. It is only when the world is envisaged from a technicist perspective and man is envisaged from a religious perspective that one can be called a complete object and the other a complete subject. Pure objectivity and pure subjectivity are modes of the mediation between man and the world, in their first form.

Religion and technics are the organization of two symmetrical and contrasting mediations; but they form a couple, since each is but one phase of the primitive mediation. In this sense, they do not have a definitive autonomy. Furthermore, even when taken in the system that they form, they cannot be considered as enclosing all the real, since they are between man and the world, but do not contain the entire reality of man and of the world, and cannot apply to it in a complete way. Because of the gap between these two opposing aspects of mediation, science and ethics deepen the relation between man and the world. With regard to science and to ethics, the two primitive mediations play a normative role: science and ethics are born in the interval defined by the gap between technics and religion, by following the median direction; the precedence that religion and technics have to science and ethics is of the same order as the precedence that lines limiting an angle have to the bisector of that angle: the sides of the angle may be indicated by short segments, whereas the bisector can be extended indefinitely. Likewise, from the gap that exists between very primitive technics and a very primitive religion, a very elaborate science and very elaborate ethics can be progressively constructed without being limited by, but only directed by, the basic conditions of technics and religion.

The origin of the division that created technical thinking and religious thinking can be attributed to a primitive structure of reticulation that is truly functional. This division separated figure from ground, figure providing the content of technics, and ground providing that of religion. Whereas in the magical reticulation of the world, figure and ground are reciprocal realities, technics and religion emerge when figure and ground become detached from one another, in this way becoming mobile, divisible, displaceable, and directly open to

manipulation because disconnected from the world. Technical thinking retains only the schematism of structures, of what makes up the efficiency of action on singular sites; these singular sites, detached from the world of which they were the figure, detached also from one another, losing their immobilizing reticular concatenation, become divisible and receptive as well as reproducible and constructible. The elevated place becomes an observation post, a watchtower constructed in the plain, or a tower placed at the entrance to a gorge. At the beginning, technics are often content to develop a privileged place, as when constructing a tower at the summit of a hill, or placing a lighthouse on a promontory at the most visible point. But technics can also successfully create the functionality of privileged sites. Of natural realities technics retain only the figural power, not the site and natural localization on a determined ground given prior to any human intervention. Dividing the schematisms more and more, it makes something into a tool or an instrument, that is to say, a fragment detached from the world capable of working efficiently in any location and under any conditions, site by site, according to the intention that directs it and at the moment when man so wishes. The accessibility of the technical thing consists in its being freed from servitude to the ground of the world. Technics are analytic, operating progressively and by contact, leaving aside connection by influence. In magic the singular place permits action over a whole domain, just as talking to the king is enough to win over a whole people. In technics, on the other hand, all of reality must be examined, touched and treated by the technical object, detached from the world and available for use in any site at any moment. The technical object is distinguishable from the natural being in the sense that it is not part of the world. It intervenes as mediator between man and the world; it is, therefore, the first

detached object, for the world is a unity, a milieu rather than an ensemble of objects; there are in fact three types of reality: the world, the subject, and the object, which is an intermediary between the world and the subject, the primary form of which is the technical object.

III. – DIVERGENCE OF TECHNICAL THINKING AND OF RELIGIOUS THINKING

Technical thinking, which results from the rupture of the primitive reticular structure of the magical world, and which retains those figural elements that can be deposited in objects, tools, or instruments, gains from this detachment an accessibility that makes possible its application to every element of the world. However, this rupture also produces a deficit: the tool or the technical instrument has retained only its figural characteristics, and figural aspects that are detached from the ground with which they had once been directly connected since they came from a primary structuring that caused figure and ground to spring up as a single and continuous reality. In the magical universe, the figure was the figure of a ground and the ground the ground of a figure; the real, the unity of the real, was at once figure and ground; the question of a possible lack of effectiveness of the figure on the ground or of the influence of the ground on the figure could not have arisen, since figure and ground constituted a single unity of being. On the other hand, in the case of technics, after the rupture, what the technical object retained of figural characteristics and made them permanent finds any ground whatever anonymous and foreign. The technical object has become a bearer of form, a remnant of figural characteristics, and it tries to apply that form to a ground that is now detached from the figure, because it has lost its intimate inherent

relationship and because it can be informed by any form encountered, but in a violent, more or less imperfect manner; figure and ground have become strangers and abstract in relation to one other.

The hylemorphic schema does not solely describe the genesis of living beings; it might not even describe it essentially. Perhaps also it does not derive from a well-thought-out and conceptualized experience of technics: before the knowledge of the living being and before reflection on technics, this implicit adequacy of figure and ground is broken by technics. If the hylemorphic schema seems disengaged from technical experience, this is because it is more a norm and an ideal than an experience of the real. Technical experience, making use of vestiges of figural elements and vestiges of ground-characteristics, revives the primary intuition of a mutual adherence of matter and form, of a coupling preceding any division. In this sense, the hylemorphic schema is correct, not because of the logical use of it in ancient philosophy, but as an intuition of the structure of the universe for man before the birth of technics. This relation cannot be organized as a hierarchy: it cannot have in it increasingly successive and increasingly abstract stages of matter and of form, because the real model of the relation between matter and form is the primary structuring of the universe as figure and ground; now, this structuring is true only if it is not abstract, if it is at one stage only; the ground is really ground and the figure really figure, and it cannot become ground for a higher figure. The manner in which Aristotle describes the relations between form and matter, in particular the supposition that matter aspires to form (matter aspires to form as the female to the male) is already far from primitive magical thinking, for that aspiration can only exist if there had been an earlier detachment; so, it is a single being that is at once matter and form.

Furthermore, perhaps one should not say that only the individual being is made up of matter and form; because the emergence of a figure-ground structure is prior to any segregation of units. The mutual relation of correspondence between a given key-point and a given ground neither presupposes the isolation of the key-point from the network of other key-points nor the discontinuity of this ground from other grounds: it is a universe that is structured in this way, not an ensemble of individuals. The first detached beings to emerge after the rupture of the primitive reticulation are technical objects and religious subjects, and they are responsible for figural characteristics as they are for ground characteristics: therefore, they do not fully possess matter and form.

The dissociation of the primitive structuring from the magical universe entails a series of consequences for technics and religion, and through them it conditions the later development of science and of ethics. In fact, unity belongs to the magical world. The phase-shift that makes for an opposition between technics and religion, in an irreducible way leaves technical content with a status lesser than unity and leaves religious content with a status greater than unity. This causes all the other consequences. A proper understanding of the status of the technicity of objects depends on its being grasped in terms of the development that put the primitive unity out of phase. Religion, retaining its ground characteristics (homogeneity, qualitative nature, indistinction of elements within a system of mutual influences, long-range action across space and time resulting in ubiquity and eternity), represents the implementation of the functions of totality. A particular being, a precise object of attention or of effort, is always considered in religious thought to be smaller than real unity, inferior to the totality and included within it, exceeded by the totality of space,

and preceded and followed by the immensity of time. Whether subject or object, the object, the being, the individual is always understood to be less than unity, to be dominated by a presaged totality that infinitely transcends it. The source of the transcendence lies in the function of totality that dominates the particular being; in the religious view of things this particular being is understood in relation to a totality in which it participates, because of which it exists, but which it can never completely express. Religion universalizes the function of totality, which is dissociated and consequently freed from any figural attachment that limits it; the grounds connected to the world in magical thinking and consequently limited by the very structuring of the magical universe, become in religious thinking a limitless background, spatial as well as temporal. They retain their positive ground qualities (forces, powers, influences, quality), but rid themselves of their limits and the adherence that attached them to a *hic et nunc.* They become absolute ground, totality of ground. Advancement in the universe begins from liberated and, to some extent, abstract magical grounds.

Religious thinking, after the disjunction of ground and figure, retains the other part of the magical world: the ground, with its qualities, its tensions, its forces; but this ground, too, like the figural schemas of technics, becomes something detached from the world, abstracted from the primitive milieu. And just as the figural schemas of technics, freed from their adherence to the world, are affixed to tool or instrument in the course of becoming objectified, the qualities of ground that technicity makes available in the mobilization of figures are affixed to subjects. Technical objectification leading to the emergence of the technical object, the mediator between man and the world, has a counterpart in religious

subjectification. Just as technical mediation is instituted by means of something that becomes a technical object, so religious mediation emerges as a result of the affixing of ground characteristics on subjects, real or imaginary, divinities or priests. Religious subjectification normally leads to mediation by the priest, while technical mediation leads to mediation by the technical object. Technicity retains the figural characteristics of the primitive complex of man and the world, while religiosity retains the ground characteristics.

Technicity and religiosity are neither degraded forms of magic nor relics of magic; they issue from the division of the primitive magical complex, the reticulation of the original human milieu into figure and ground. It is through their coupling that technics and religion are the heirs of magic, not through each on its own. Religion is not more magical than technics; it is the subjective phase of the result of division, whereas technics are the objective phase of the very same division. Technics and religion are contemporaries of each other, and, when each is taken separately, they are more impoverished than the magic from which they emerge.

Religion, therefore, has by nature the vocation to represent the exigency of the totality; when it divides into a theoretical mode and a practical mode, through theology it becomes the exigency of a systematic representation of the real as an absolute unity; through morality, it becomes for ethics the exigency of absolute norms of action that are justified in the name of the totality and superior to all hypothetical, that is to say particular, imperatives; to science as to ethics, religion brings a principle of reference to the totality, which is the aspiration to the unity of theoretical knowledge and to the absolute character of

the moral imperative. Religious inspiration constitutes a permanent reminder of the relativity of one particular being with respect to an unconditional totality exceeding every object and every subject of knowledge and of action.

Conversely, technics have a content that is always subordinate to the status of the unity, because the schemas of efficiency and the structures resulting from the fragmentation of the primitive network of key-points cannot be applied to the totality of the world. By nature, technical objects are multiple and divided; technical thinking, enclosed in this plurality, can progress, but only by multiplying technical objects, without being able to recapture the primitive unity. Even when multiplying technical objects endlessly, it is impossible to find an absolute adequacy to the world, since each of the objects attacks the world in one place only and in one moment only; it is localized, particularized; adding technical objects one to another can neither re-make the world nor regain contact with the world in its unity, which was the aim of magical thinking.

In connection with a specific object or with a specific task, technical thinking is always inferior to unity: it can present several objects and several means, and select the best; but nonetheless, it always remains inadequate to the wholeness of the unity of the object or of the task. Each schema, each object, each technical operation, is controlled and guided by the whole from which it derives its ends and its orientation, and which provides it with a never attained principle of unity that is expressed by combining and multiplying its schemas.

Technical thinking has by nature the vocation to represent the point-of-view of the element; it adheres to the elementary function. Once technicity is admitted into a domain it

breaks it up and starts a chain of successive and elementary mediations governed by the unity of the domain and subordinated to it. Technical thinking conceives the operation of an ensemble as a chain of elementary processes working point by point and step by step; it localizes and multiplies the schemas of mediation, always remaining lesser than the unity. The element in technical thinking is more stable, better understood, and in a certain way more perfect than the ensemble; it is really an *object*, whereas the ensemble always remains to a certain extent inherent in the world. Religious thinking finds the opposite equilibrium: in it, the totality is more stable, more powerful, and more viable than the element.

In the theoretical domain as in the ethical domain, technics are concerned with the element. In the sciences the contribution of technics consisted in making possible a representation of phenomena one by one by breaking them down into simple elementary processes similar to the operations of technical objects; such is the role of the mechanistic hypothesis that enabled Descartes to represent the rainbow as an overall result of the point by point trajectory taken by each luminous corpuscle in each drop of rain in a cloud; and it was also according to the same method that Descartes describes the functioning of the heart by breaking down a complete cycle into simple successive operations and showing that the functioning of the whole is the result of the play of elements necessitated by their particular disposition (for example, that of each valve). Descartes does not ask himself why the heart is made in this way, with valves and cavities, but how it works given how it is made. The application of schemas drawn from technics does not account for the existence of the totality, taken as a unity, but does account for the point by point and instant by instant functioning of that totality.

In the ethical domain, technical thinking not only introduces means of action that are fragmentary and tied to the capacities of each object that is becoming a utensil, but also a certain reduplication of the action by technicity; a specific human action, considered with respect to its results, could have been accomplished by a specific technical functioning going through various stages; elements and moments of action have their technical analogue; an effort of attention, of memory, could have been replaced by a technical operation; technicity provides a partial equivalence to the results of action; it accentuates awareness of the action by the being who brings it to completion in the form of results; it broadcasts and objectifies the results of the action through comparison with those of the technical operation, breaking down the action into partial results, into elementary completions. Just as in the sciences technicity introduces the search for the *how* by a breaking down of ensemble phenomena into elementary operations, so, in ethics technicity introduces the search for a breaking down of the overall action into the elements of action; because the total action is envisaged as that which produces a result, the breakdown of the action generated by technics considers the elements of the action as gestures that achieve partial results. Technicity assumes that an action is limited to its results; it is not concerned with the subject of the action taken in its real totality, nor even with an action in its totality, to the extent that the totality of the action is founded on the unity of the subject. In ethics concern with results is the analogue of the search for the *how* in the sciences; result and process remain subordinate to the unity of the action or to the ensemble of the real.

The postulation of an absolute and unconditional justification which religion directs toward ethics translates into a search for the intention as opposed to a search for the result that is inspired by technics. In the sciences, religious thinking introduces an appeal for absolute theoretical unity that requires a search for the sense of becoming and the existence of given phenomena (hence responding to the *why?*), whereas technical thinking offers an examination of the *how?* for each of the phenomena.

Because its content is inferior to unity, technical thinking is the paradigm for all inductive thinking, both in the theoretical order and in the practical. It contains this inductive process in itself, prior to any separation into practical and theoretical modes. Induction, in fact, is not merely a logical process in the strict sense of the term; any process can be considered to be a process of the inductive type if its content is inferior the status of unity, if it strives to attain unity or, at least, if it tends toward unity from a plurality of elements, each of which is inferior to unity. What induction takes hold of, what it starts from, is an element that in itself is not sufficient and complete, and does not constitute a unity; so, it exceeds each particular element by combining it with other elements that are themselves particular, in order to find an analogue of unity: in induction there is a search for the ground of reality from figural elements that are fragments; to try to find a law beneath phenomena, as in the induction of Bacon and Stuart Mill, or to try to find only what is common to all individuals of a given species, as in Aristotle's induction, is to postulate that beyond the plurality of phenomena and of individuals there exists a stable and common ground for reality, that is the unity of the real.

It is no different in ethics that would directly derive from technics; to want the whole duration of life to be a series of moments, to extract from each situation what is pleasant in it, and to want to construct the happiness of life by accumulating its agreeable elements, as did ancient Eudaimonism or Utilitarianism, is to proceed in an inductive manner, by trying to replace the unity of the duration of life and the unity of human aspiration with a plurality of instants and with the homogeneity of all successive desires. The elaboration to which Epicureanism submits desires has one goal only, which is to incorporate them into the continuity of an existence that proceeds in an accumulative manner: for this, each of the desires must be dominated and surrounded by the subject, made lesser than unity, so that it can be treated and manipulated as a genuine element. This is why the passions are eliminated, since they cannot be treated as elements; they are larger than the unity of the subject; they dominate it, they come from farther away than it and tend to go farther on than it, obliging it to exceed its limits. Lucretius tries to destroy the passions from within, by showing that they are based on errors; in fact, he fails to account for the element of tendency in passion, that is to say, for the force that is inserted into the subject and yet is more extensive than it, a force in relation to which it seems to be a very limited being; tendency cannot be considered to be contained within the subject as a unity. Wisdom, having restored the forces at the origin of action to a status of inferiority with respect to the unity of the moral subject, can organize them as elements and reconstruct a moral subject within the natural subject; however, this moral subject never completely attains the level of unity; between the reconstructed moral subject and the natural subject there remains a void impossible to fill; the inductive approach remains in plurality; it constructs a network of

elements, but this network cannot amount to a real unity. All ethical technics leave the moral subject unsatisfied because they ignore its unity; the subject cannot be content with a life that would be a series, even an uninterrupted series, of happy moments; a life that is perfectly successful element by element is still not a moral life; it lacks what makes it the life of a subject: unity.

But conversely, religious thinking, the foundation of obligation, creates in ethical thought a search for unconditional justification which makes every act and every subject appear to be inferior to real unity; when related to a totality that expands endlessly, the moral act and subject derive their significance solely from their relation with this totality; the communication between the totality and the subject is precarious, because at every moment the subject is drawn back to the dimension of its own unity, which is not that of the totality; the ethical subject is de-centered by religious exigency.

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On the Mode of Existence of Technical Objects
by
Gilbert Simondon

THIRD PART

THE ESSENCE OF TECHNICITY

CHAPTER II

RELATIONSHIPS BETWEEN TECHNICAL THOUGHT AND OTHER KINDS OF THOUGHT

I.—TECHNICAL THOUGHT AND AESTHETIC THOUGHT

According to a certain genetic hypothesis, one should not expect different modes of thinking to be parallel to each another; hence, one cannot compare religious thinking and magical thinking because they are not on the same plane; but on the other hand it is possible to compare technical thinking and religious thinking because they are contemporaneous with one another; to compare them it is not enough to define their particular characteristics, as if they were species of a genus; we need to recapture the genetic accomplishment of their formation, because they exist as a couple, as a result of the bifurcation of a [once] complete primitive thought, magical thinking. As for aesthetic thinking, it is never a limited domain or a given species, but just a trend; it is what maintains the function of the whole. In this sense, it can be compared to magical thinking, as long as it is clear that, unlike magical thinking, it has no possibility of being split into technics and religion; far from going in the direction of bifurcation, aesthetic thinking sustains the implicit memory of the unity; from one of the phases of the bifurcation it calls on the other complementary phase; it looks for the totality of thought and aims at reconstructing unity by an analogical relation at the point where the onset of phases could create the mutual isolation of thought in relation to itself.

Without doubt, such a way of contemplating aesthetic effort would miss the point if we wanted to characterize in kind works of art as they exist at the institutional level in a given civilization, and all the more so if we wanted to define the essence of aestheticism. But if they are to be possible, works of art have to be made possible by a fundamental tendency in human nature and by a capacity for having an aesthetic impression in certain real and vital circumstances. The work of art as part of a civilization uses the aesthetic impression and, sometimes artificially and in an illusory way, satisfies the human tendency in exercising a particular kind of thinking to find the complement in relation to the whole. It would be inadequate to say that the work of art is evidence of a nostalgia for magical thinking; in fact, the work of art gives the equivalent of magical thinking, because from a given situation, and according to a structural and qualitative analogical

relations, it retrieves a universalizing continuity in relation to other possible situations and to other possible realities. The work of art.........